Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

MATERIALS FOR SPRINGS

Manual No. 161

Also: Bituminous Coatings

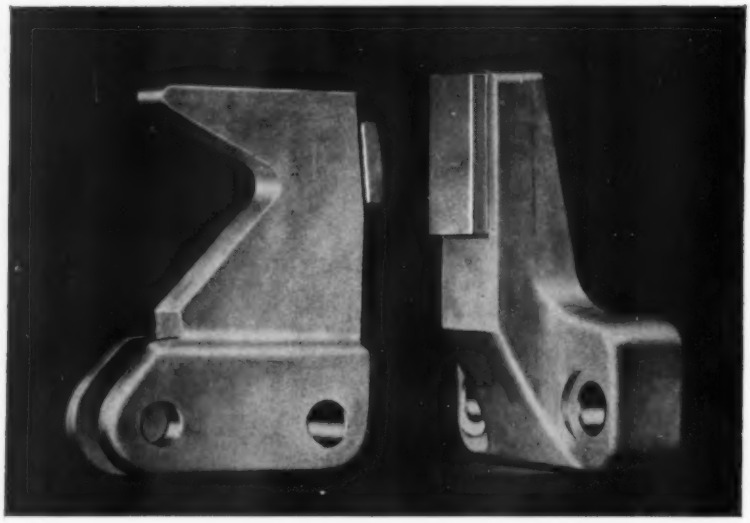
Special Report:
Vacuum Melted Alloys

Complete Contents—
page 1

UGUST, 1959

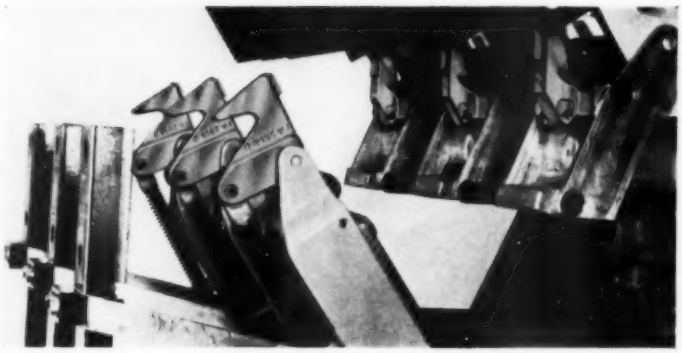
TWICE-WROUGHT METAL

of die-pressed forgings helps Federal Pacific make new air circuit breakers more rugged—cuts machining costs in half

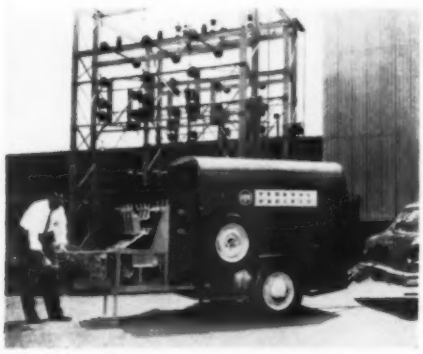


In its new Type DST magnetic air circuit breaker line, Federal Pacific Electric Company, Newark, N. J., builds in dependable operation and long life with parts of outstanding mechanical and adequate electrical properties.

Typical of this attention to detail are the arcing contacts (left). Similar parts previously used had been castings or built-up assemblies. Now the contact bodies are Anaconda Forging Brass-250 die-pressed forgings. The twice-wrought metal is denser, stronger, withstands mechanical shock better—reducing the fatigue factor and producing longer service life. The contacts also have higher conductivity. And best of all, their consistent dimensional accuracy and smooth finish cut machining costs in half.



RIGHT: Movable arcing contact assemblies at the left and the stationary arcing contact assemblies at the right in a 5-kv Federal Pacific Type DST air circuit breaker. They have a momentary current-carrying capacity of 60,000 amperes. Contact tips of tungsten alloy are silver-soldered to the forgings. These are two of several areas where Federal Pacific uses the superior physical properties of Anaconda die-pressed forgings to help provide dependable operation and long service life in its line of metal-clad switchgear.



Federal Pacific takes its circuit breakers out to industrial and electric utility customers. Here a representative sets up a demonstration of a 5-kv, 1,200-amp breaker in the field.

IT IS often easier than you think to achieve high quality and performance while simplifying fabrication and cutting over-all costs. American Brass technical specialists are constantly working with designers, production engineers and buyers, helping them meet their joint requirements—through the use of such Anaconda mill products as die-pressed forgings, extruded shapes, special-shape tubes. For this kind of practical help, see your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Toronto 14, Ontario. 2944

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Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

AUGUST 1959
VOL. 50, NO. 2

FEATURES

Vacuum Melted Metals and Alloys—Why Use Them? ..... *J. L. Everhart* **89**
A special report tells how you can get added toughness and uniformity in critical parts

Short-Time Test Predicts Fatigue Strength of Plastics ..... *L. S. Lazar* **98**
Endurance limits based on progressive stress method come very close to conventional data

Bituminous Coatings ..... *S. H. Alexander, R. D. Cunningham* **100**
They resist weathering and abrasion, provide good insulation and have long service life

How to Interpret Mechanical Properties of Elastomers **105**
Terms such as hardness, tensile strength, etc. have special meanings when applied to rubber

High Temperature Corrosion of Metals ..... *C. J. Guare* **110**
What you should know about the effects of composition, thermal cycling and many other factors

MANUAL NO. 161

Materials for Springs ..... *J. T. Milek* **115**
Here are the 35 most popular spring materials—their significant properties plus tabular comparisons

DEPARTMENTS

MATERIALS AT WORK **7**
At a Glance—*7*. Porcelain Enamel Coatings for Small Parts—*10*. Teflon Replaces Stainless Steel in Heart-Lung Machine—*12*. Other Contents—*12*.

PRICES AND SUPPLY—AT A GLANCE **19**

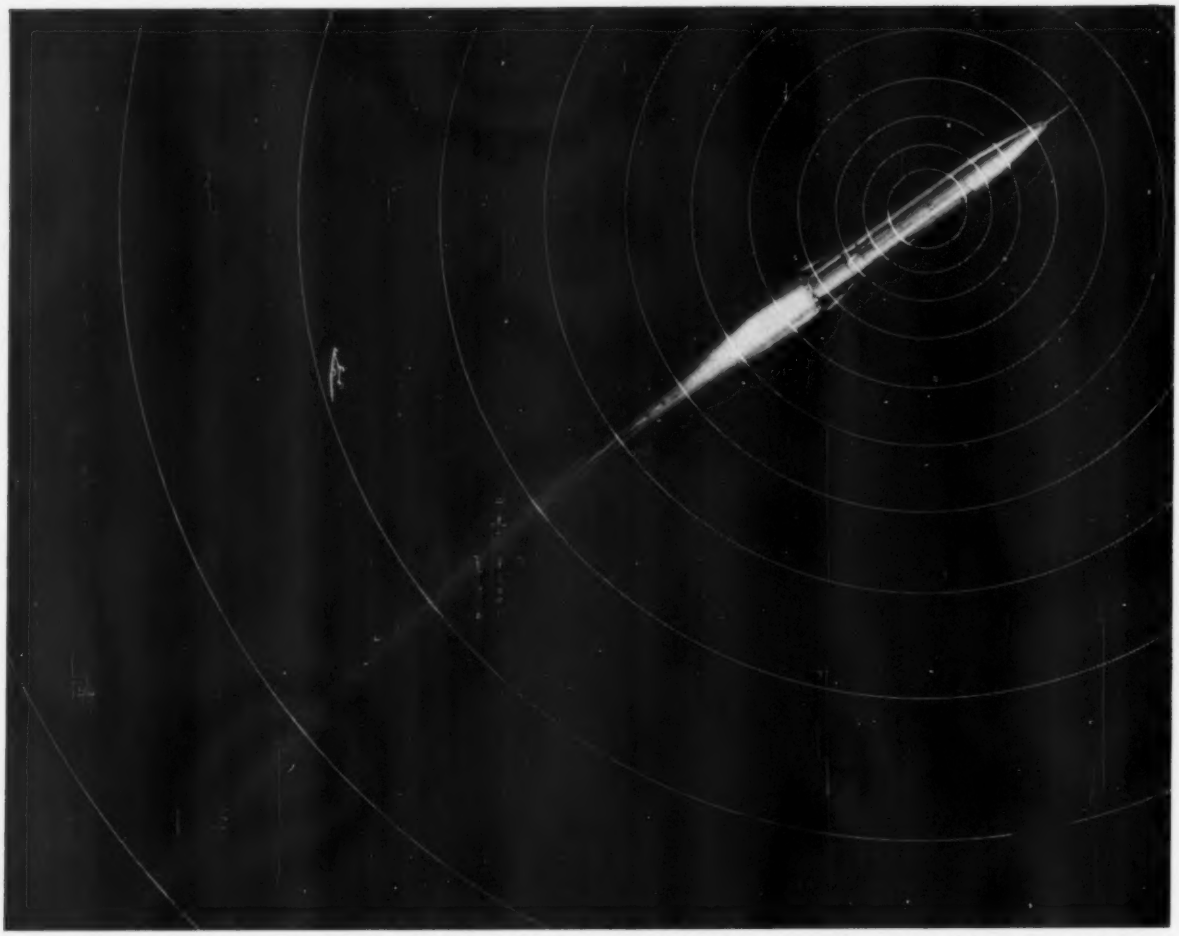
TECHNICAL LITERATURE **38**
Suppliers' New Bulletins—*38*. Books—*208*. Reports—*208*.

FILE FACTS **129**
ABS Resins and Methylstyrenes—Materials Data Sheet

WHAT'S NEW IN MATERIALS **131**
At a Glance—*3*. Strong, Workable Titanium Tubing—*131*. Ethylene-Propylene Copolymer—*131*. Better Vacuum Metallized and Vapor Plated Coatings—*132*. Three Magnesium Alloys for High Temperatures—*134*. Other Contents—*134*.

NEWS OF INDUSTRY **191**
Better Materials Education Needed—*191*. Research Before Hardware—*194*. News of Engineers—*196*. Companies—*200*. Societies—*204*. Meetings—*206*.

OTHER DEPARTMENTS
Letters—*14*. Reader Service—*35*. Advertisers: *214*, Product Index—*37*. Last Word—*216*.



Things happen fast to a rocketing missile. High-nickel Mumetal shields help tape recorders get it all down accurately.

How Nickel helps record messages from space

When a missile rockets off into space, it detects all sorts of data – temperature, radiation, meteoric dust – the many things we need to know in order to conquer space.

Since radio transmission and reception between missile and ground is not always reliable, some missiles carry an airborne secretary–a multi-channeled tape recorder.

It records as many as thirty different bands of data side by side on a 1½-inch magnetic tape.

Confusion of all the magnetic fields crammed inside the tiny head could cause messages to come out garbled.

But there is a way to keep them straightened out–by using Mumetal* (77% Nickel). This alloy has the unusual ability of soaking up magnetic fields like a sponge. Thin, flat shields of Mumetal siphon off troublesome interference.

The manufacturer also covers the whole head with more Mumetal to bar stray magnetic fields on the outside from getting inside. And then a protective Nickel-chrome plating goes on top of that.

All in all, it's quite a job Nickel does. And something to keep in mind the next time you're faced with a problem in your product or process. If it has to do with high or low temperatures . . . magnetism . . . corrosion . . . fatigue or some other factor, write us. We'd be happy to show you how Nickel, or one of its alloys, may be able to help.

Tiny magnetic head of tape recorder has Mumetal shields to trap magnetic interference, help Davies Lab. Division of Minneapolis-Honeywell pack much in little space. Nickel-chrome plating on cover adds durability, corrosion resistance, and attractive appearance.

*Trademark, Allegheny Ludlum Steel Corporation

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INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

What's new IN MATERIALS

...AT A GLANCE

Ductile molybdenum sheet, said to have far greater ductility than any molybdenum sheet previously available, is being made in commercial quantities. According to the developer, the new high ductility sheet can be bent double without cracking or breaking at room temperature; the limit for ordinary molybdenum sheet is only about 20 deg. It may now be possible to form thick sections of molybdenum sheet by Hydroforming. (More details next month.)
Source: General Electric Co., Lamp Metals & Components Dept., Nela Park, Cleveland 12.

Seven easy-to-process silicone rubbers have been introduced. They include 1) two general purpose compounds, 2) two wire and cable compounds, 3) a general purpose silicone rubber masterbatch, 4) a fluoro-silicone rubber masterbatch, and 5) a fuel and solvent resistant fluoro-silicone rubber. (More details next month.)
Source: Dow Corning Corp., Midland, Mich.

A beryllium airframe structure has been constructed by a group of engineers who have worked out suitable methods for fabricating beryllium into relatively non-brittle sheet. The engineers say that ordinary thermal insulation will probably be sufficient to keep beryllium structures cool. Thus, airframes will not require the complicated cooling systems currently used on missiles.
Source: Martin Co., Baltimore 3, Md.

Thin beryllium wire (0.090 in.) has successfully been drawn from 0.250-in. dia rod on standard wire drawing equipment, using a specially designed preheat furnace. The most critical variables in drawing beryllium wire seem to be temperature, die design, crystallography and starting material. Hot pressed beryllium rod is the most promising starting material evaluated to date.
Source: Brush Beryllium Co., 4301 Perkins Ave., Cleveland 3.

Wear resistant, deep black, chromium electroplates result from a new plating technique that operates at current densities from 150 to over 450 asf, and at temperatures from 70 to 100 F. The electroplates are said to have about three times the wear resistance of bright nickel. According to the developer, the electroplate could probably be substituted for hard or porous chromium in a number of applications.
Source: Dr. A. K. Graham, Savage & Asso., Inc., 475 York Rd., Jenkintown, Pa.

A new plastic, polybutene, joins the growing family of "isotactic" materials that have been introduced during the past few years (polypropylene plastic, M/DE, Jan '58, p 110 and Feb '58, p 155, and polypropylene rubber, this issue, p 131). Limited property data indicate the new isotactic plastic has high tear strength. The plastic is now in pilot plant production in Italy.
Source: Chemore Corp., 2 Broadway, New York 4.

Laminated aluminum sheets, made by bonding 10 to 13 layers of aluminum foil together with an epoxy resin, have shown a remarkable ability to completely halt

crack propagation in a recent series of fatigue tests. The laminated sheets, currently under evaluation, are 7 to 10% less dense than the parent metal foils. Tensile tests show the laminated sheets have the same and possibly better strength properties than solid aluminum sheet of the same thickness.

Source: R. B. Baird, Aeronautical Research Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio.

Metal powder-lead alloys are reported to combine the properties of lead (corrosion and radiation resistance) with the properties of other metals (strength, heat resistance, etc.). Research to date shows that cobalt, copper, iron, molybdenum, nickel and tungsten powders are particularly well suited for the new alloys. The alloys are made by mixing treated metal powders with molten lead.

Source: Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

Inexpensive aluminum-coated steel strip, analogous to tinplate, may result from research now being conducted on continuous vacuum metallizing. Strip presently contemplated would be comparable to ¼-lb tinplate, coating thickness being about 0.030 mil. Such strip seems promising as a less expensive substitute for tinplate for containers.

Source: Research Center, Republic Steel Corp., Independence, Ohio.

An experimental magnesium alloy can be forged to commercial tool design tolerances with either hydraulic or heavy presses, according to a recent Air Force report. The material, alloyed with the rare earths neodymium and praseodymium, is said to have outstanding strength and creep resistance in the T6 condition. Its modulus, impact and shear strength, and its hardness, though comparable to those of AZ80A-T5 alloy at room temperature, are far superior at high temperatures.

Source: Rpt. No. PB 151536, Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D.C.

Pressed and sintered porous nickel sheets and cylinders are being made by a new process. The shapes were developed specially to serve as noncontacting conveyors for processing extra-sensitive materials, such as molten glass, plastics, adhesives and camera film. Products ride on a thin cushion of air forced through the pores of the material. The porous nickel can operate at temperatures up to 575 F. (More details next month.)

Source: Corning Glass Works, Corning, N. Y.

Titanium unfired pressure vessels are now covered by the ASME Code (Case No. 1258). The Code specifies that the base material be unalloyed titanium conforming in chemical composition and mechanical properties to ASTM specifications for Grades 1, 2 and 3 of B265-58T. The Code also specifies allowable stress values for the three grades of titanium at temperatures from 70 to 650 F.

Source: Copies of the code covering titanium are available from Titanium Metals Corp. of America, 233 Broadway, New York 7.

Lower cost stainless steel honeycomb structures may be realized by using newly developed, flexible wire mesh heating elements for brazing instead of a furnace. The heating elements operate at low currents, and heat by conduction rather than radiation or convection. Tests show that the heating elements withstand 50 cycles from room temperature to 1800 F.

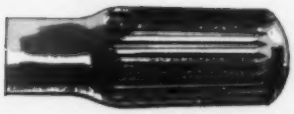
Source: Electrofilm, Inc., P. O. Box 166, North Hollywood, Calif.

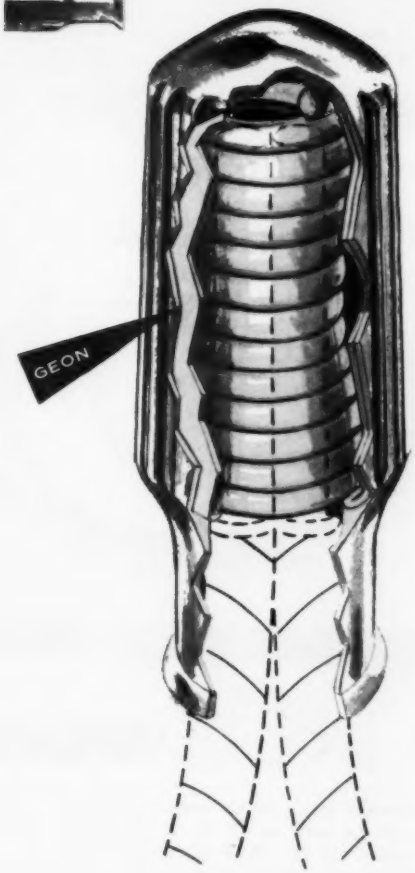
Turn to page 131 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*

"Scotchlok" Brand electrical spring connectors, designed to give tons of holding pressure in a fraction of an ounce, are made by Minnesota Mining And Manufacturing Company, St. Paul, Minn., using caps molded of Geon by Minnesota Plastics Corporation, St. Paul. B.F.Goodrich Chemical Company supplies the Geon polyvinyl material.





High holding splices with a twist...

NEW CONNECTORS ARE CAPPED WITH GEON

Just three color coded sizes of this "Scotchlok" Brand electrical wire connector can splice over 400 wire combinations from 6 to 18 AWG solid and stranded. It consists of a bell-shaped steel spring in a hard steel shell, all fitted into a cap molded from Geon polyvinyl material.

Geon makes a tough and flexible cap. It has a long, conforming skirt to prevent flashover. And since Geon can be precision-molded, there is a knurled surface to provide finger grip, making it easier to twist the connector onto wire ends. Geon can also be molded in colors—each of the different sizes has its own color code.

Geon also provides ideal electrical characteristics. And it offers good resistance to abrasion, weathering, and heat, as well as non-flammability and low-temperature flexibility. In addition, Geon is inert to oil, chemicals and solvents.

The new U.L.-approved connector is providing permanent high-pressure splices for fixture and appliance applications, as well as for larger size wire in homes and industry. It's an example of the way that Geon makes possible new products, or new applications of existing ones. For more information, write Dept. AR-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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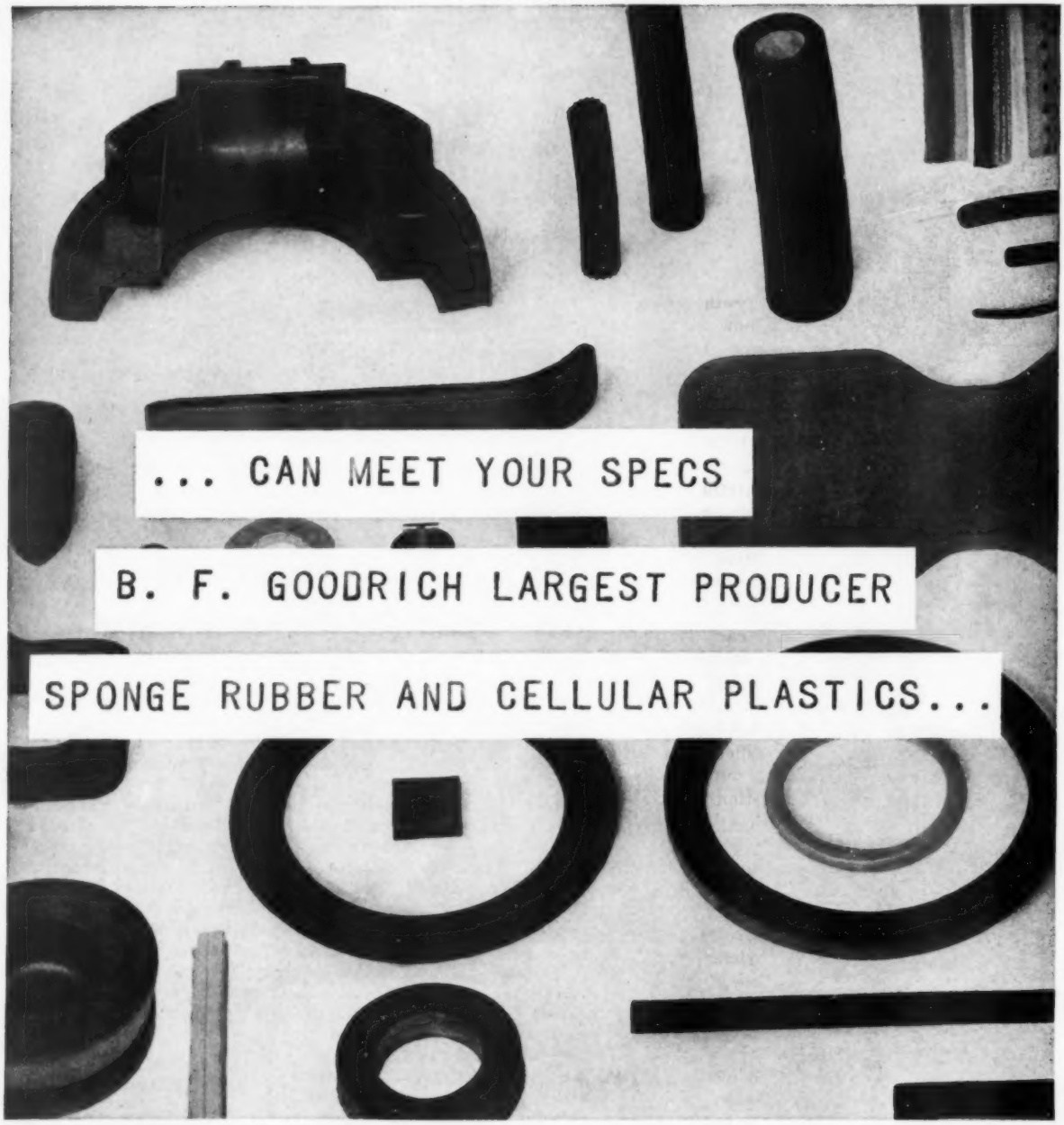

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MATERIALS AT WORK

...AT A GLANCE

Storage tanks blanketed with urethane foam

Urethane foam "blankets" are now being used to insulate exteriors of storage tanks. The 1-in. thick blankets, which have proved successful on small indoor hot water tanks as well as large outdoor tanks measuring 24 ft in dia and 30 ft high, are simply taped to the tank and coated with two layers of an asphalt mastic reinforced with a glass fiber membrane. Although cost of the urethane insulation material is "slightly higher" than that of conventional low temperature materials, overall cost of installation is said to be competitive.

Source: Mobay Chemical Co.; insulation applied by Armstrong Contracting & Supply Co.

Stainless mufflers may outlast car

The switch from mild steel to stainless steel may result in automobile mufflers that last as long as the automobile itself. Presently used mufflers burn out in about 1½ years, or about 15,000 miles. Results of tests indicate that most muffler failures result from corrosion caused by strong sulfuric and hydrochloric acids produced by combustion. This corrosion is accelerated when the muffller operates at about 180-200 F. Thus far, types 430, 304 and 310 stainless have been found to resist corrosion.

Source: Allegheny Ludlum Steel Corp.

Coated cardboard protects typewriters

Thanks to an ultra-thin polyethylene coating, heavy electric typewriters are now being transported in lightweight cardboard containers. The polyethylene resin, which is claimed to be the only material that did not damage the machine's finish during shipment, is extrusion-coated on the inner surface of a specially designed box board liner. The liner fits over the typewriter and is said to protect it from all damage, even if the box is turned upside down.

Source: E. I. du Pont de Nemours & Co.; box manufactured by Mengel Co., Div. of Container Corp.

Terne-coated steel used for air cleaners

Terne-coated steel is now being specified for the housings of heavy duty air cleaners. Here's why: housing bodies and cup shells can be drawn from the same blank; residual oil on the steel from the coating process serves as a lubricant; no surface preparation is needed to assure good paint adherence; the material is corrosion resistant; and soldering is fast and efficient.

Source: Armco Steel Corp.; cleaners manufactured by Vortox Co.

Flame spraying furnace cooler frames

Flame sprayed alloy or ceramic coatings may extend the life of cooler frames used on open hearth furnaces. Experiments are now being conducted with various thicknesses of chromium-nickel, zirconia and alumina coatings to determine the most economical protection system.

Source: Research Center, Republic Steel Corp.

Nylon tubing replaces copper

The replacement of copper tubing with polyamide (nylon) tubing has resulted in a cost saving of 50% in the design of equipment used to measure and record pressures in jet engines. The tubing, which has a ¼-in. o.d. and a 0.190-in. i.d., was selected in preference to copper and flexible rubber hose pri-

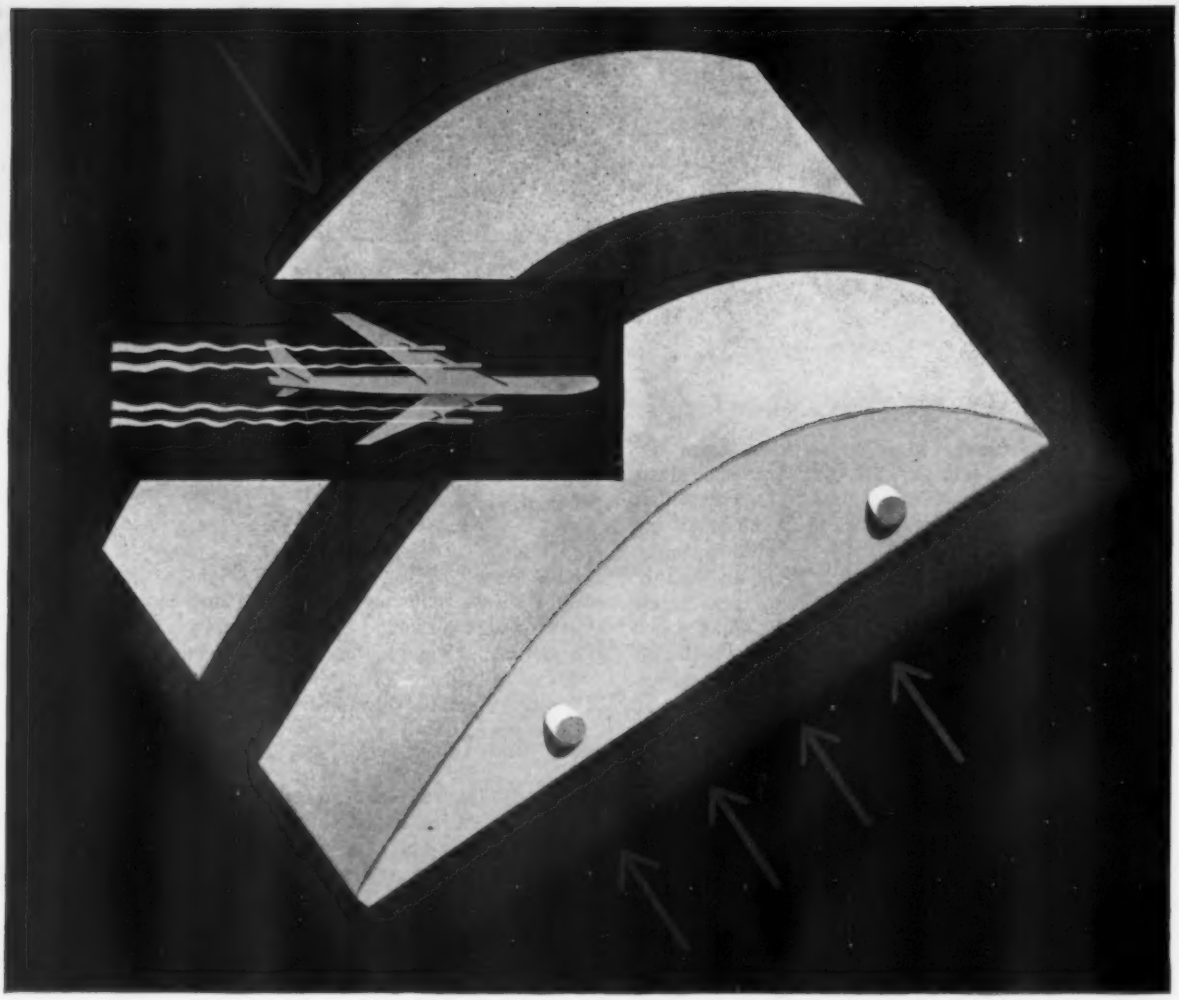
(continued on p 9)

Briefs

Molded butyrate fish are proving the old adage that all that glitters is not edible. The fish, used as lures, are lacquered in bright, fish-like patterns and are reported to be excellent for bass, pickerel, perch, trout and many other varieties of hungry fish.

Aluminum stilts are taking the stretch out of painting and other high level jobs. The stilts, which are adjustable for working areas 6 to 9 ft above the floor, weigh less than 10 lb and are easy (and fun) to use.

Foam-filled tires are said to be virtually indestructible. The tires, filled with urethane foam instead of air, are claimed to be truly blow-out-proof (they will not deflate even when cut, drilled, shot with a high powered rifle, etc.)—yet they are as comfortable as ordinary tires.



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MATERIALS AT WORK

marily because it is less expensive. It can withstand pressures of 1000 psi, as well as flex and vibrational fatigue, chemicals, wear, abrasion and a wide range of temperatures (from –100 to 225 F).

Source: Polymer Corp. of Pennsylvania; tubing used by Fischer & Porter Co.

Huge steel castings for largest stretcher

Two huge, 132-ton steel castings will form one set of jaws for a new aluminum plate stretcher. The steel castings, which are 30 ft long, 8 ft high and 8 ft thick, will be held together by six forged bolts measuring 15 in. in dia and 15 ft long. The new plate stretcher will have nearly twice the stretching power of the largest unit now in operation: it will be capable of stretching a 60-ft long, 6-in. thick aluminum plate by as much as 5 ft.

Source: Kaiser Aluminum & Chemical Sales, Inc.; stretcher built by Hydraulik G.M.B.H., Duisburg, Germany.

Phenolic paint protects wind tunnel

Use of a tough phenolic-based coating has substantially reduced maintenance costs on the interior of an 8-ft transonic wind tunnel used to study aerodynamics of aircraft shapes. Previously used paints were literally blown off the tunnel surface; the new phenolic coating has remained intact for more than two years. In addition to wind, the phenolic coating has to withstand scoring caused by bolts and other metal parts inadvertently left in the tunnel.

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp.; paint formulated by Tropical Paint Co.; used by Cornell Aeronautical Laboratory.

Newest jets use stainless

A relatively new precipitation hardening stainless steel—PH 15-7 Mo—has been selected as the main sheet material for the B-70 Valkyrie and F-108 high speed jet planes. PH 15-7 Mo was selected for the new jets (which are designed to fly at 2000 mph) because it "provides the best combination of characteristics of any metal available today for aircraft with speeds up to 2700 mph."

Source: Armco Steel Corp.; jets produced by North American Aviation, Inc.

Viton seals cut carburetor cost

Excellent dimensional stability in the presence of highly aromatic fuels is the primary reason given for the selection of Viton fluoroelastomer for a critical seal used in truck carburetor pumps. The previously used elastomeric materials tended to either shrink and cause leakage or swell and render the pump inoperative. In addition to reducing maintenance costs, the new seals are said to improve overall performance of the truck.

Source: E. I. du Pont de Nemours & Co.; seals made by Houghton Vix-Syn Co.; used by Holley Carburetor Co.

(more Materials at Work on next page)

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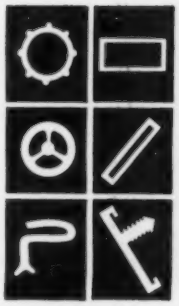

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For more information, turn to Reader Service card, circle No. 425

1. Good dielectric properties. *Because of its excellent dielectric properties, porcelain enamel provides this small piece of* electronic equipment *with a longer leakage path between the cap and the electrical leads which extend through it.*

3. Corrosion resistance. *Copper* counter wheel *for taxi meter and other recording devices is porcelain enameled to resist corrosion from moisture, gases, fumes, oils and solvents.*

2. High temperature resistance. *Porcelain enamel finish is specified for* escutcheons *of electric range heater elements and meat thermometer because it is resistant to high temperatures as well as cooking fats and greases.*

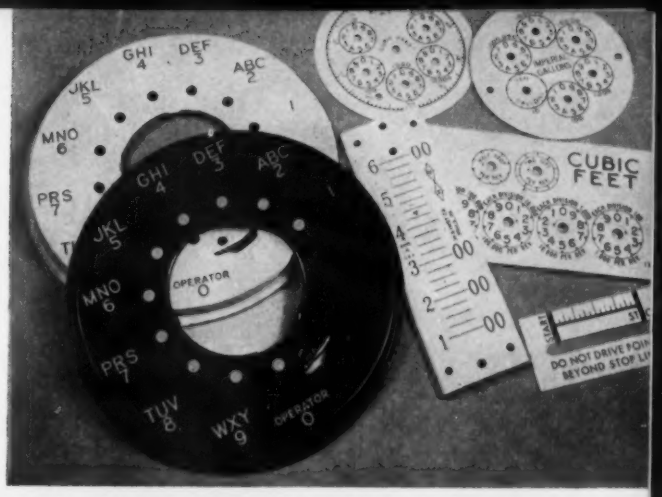
MATERIALS
AT WORK

Here are seven advantages offered by . . .

Porcelain enamel coatings for small parts

Edited by Walter Lubars

4. Low coefficient of friction. *Porcelain enamel is used at contact points of this* oil seal *because it provides a low coefficient of friction, and resistance to heat, abrasion and pressure.*



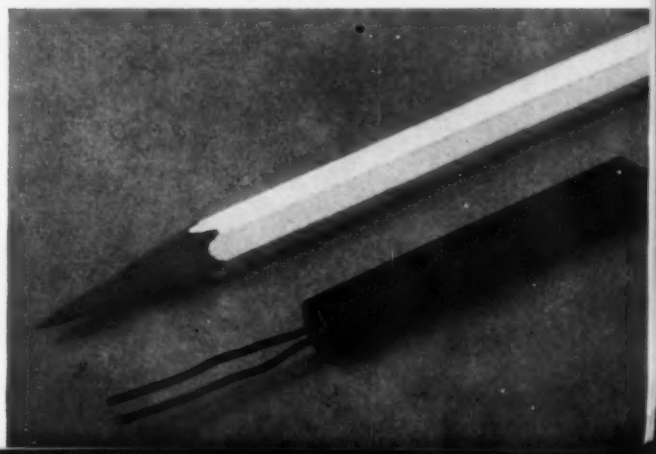
5. Abrasion resistance and durability. *Various types and sizes of* dials *use porcelain enamel for both the finish and lettering because it offers excellent resistance to abrasion (from fingernails, etc.) and excellent color retention. In addition, it resists moisture and corrosion, and is easily cleaned.*

6. Electrical insulation. *This tiny cap, used as a* terminal nut *in jet aircraft fire detector systems, is porcelain enameled across the top to prevent accidental short-circuiting.*

Although initially specified primarily for special purpose tanks, pipe linings and other large, high temperature applications, porcelain enamel coatings are now becoming increasingly popular with engineers for small parts. Reason: porcelain enamel offers an excellent combination of properties for specific end service requirements.

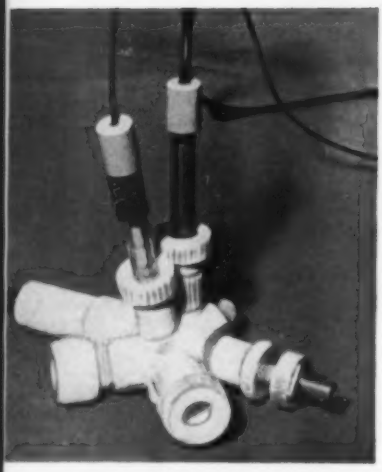
The accompanying photos show some of the small parts currently being successfully enameled by Erie Ceramic Arts Co. (For a complete discussion of porcelain enamel, see M/DE, July '58, p 103.)

7. Combination of properties. *Porcelain enamel is used to seal the end of this* thermocouple tube *for a number of reasons: it withstands heat, produces an impermeable seal, and provides electrical insulation.*

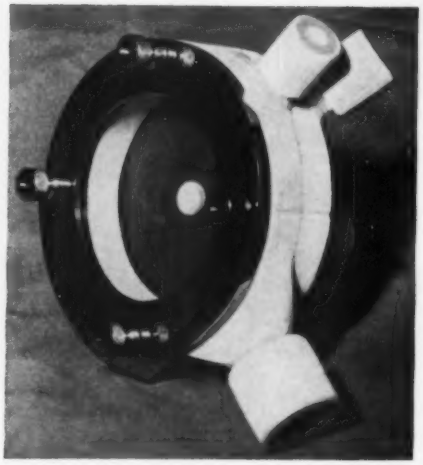


Heart-lung machine *(shown at left) "breathes" for patient during critical open-heart surgery.*

Teflon replaces stainless in heart-lung machine



Monitoring device *is hand-formed from a single rod.*



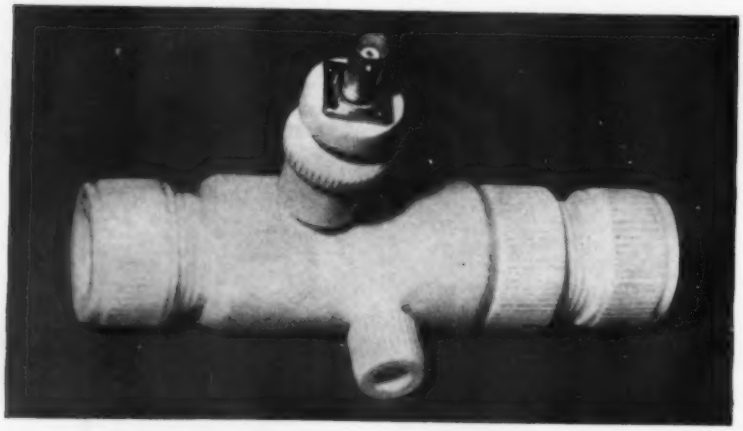
Bubble trap *prevents bubbled blood from entering the patient.*

Because TFE fluorocarbon (tetrafluoroethylene) offers an excellent combination of properties—ease of cleaning and sterilizing; extremely smooth surfaces; self-lubricating characteristics; and resistance to rust, blood chemicals, deformation, heat and cold—it has been selected to replace stainless steel for many vital parts in a heart-lung machine.

The heart-lung machine, used by the University of Colorado Medical Center during critical open-heart surgery, performs three functions: 1) it oxygenates the blood; 2) "breathes" for the patient by removing CO_2 and adding oxygen; and 3) provides a complete bypass of the heart to enable it to be drained and

(continued on p 181)

Plug connector *for monitoring device is machined from single piece of molded Teflon rod. Metal fitting is stainless steel.*



MORE MATERIALS AT WORK

Tiny hooks make unusual closure 181

Stainless bumpers will not peel, corrode..... 184

Glass-epoxy laminate cools 'copter engine..... 184

Beryllium to shield first man in orbit..... 186

PVC piping replaces copper-nickel alloy 188

"Our daily production doubled after changing to fast-curing

RCI POLYLITE

POLYESTER RESINS"

says H. D. Willcutts, prominent trailer manufacturer

That's the remarkable — and profitable — record of one company that switched to RCI POLYLITE! The H. D. Willcutts Company, Nashville, Tenn., gives full credit to the rapid curing characteristics of POLYLITE polyester resins for a 100% increase in production. The company produces trailers for Nationwide Trailer Rental System, Inc.

Panels of these vehicles also benefit via other important properties provided by POLYLITE polyester resins:

rugged strength • light weight to permit heavier payloads • outstanding resistance to corrosion • the ability to hold bolts firmly.

As a bonus, the company reports that with POLYLITE "we can now trim these panels during cure with a common linoleum knife. Previously we had to trim after cure using rotary saws with costly carbide tips."

Have *you* thought about switching to POLYLITE? Your Reichhold representative will be glad to acquaint you with the complete RCI polyester line.

Creative Chemistry ...Your Partner in Progress

REICHHOLD

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol

For more information, turn to Reader Service card, circle No. 363

engineers specify

Reevecote

Air seals	Insulation
Bearing seals	Low pressure housing
Cable wrapping	Meter diaphragms
Carburetor diaphragms	Radomes
Carrying cases	Railroad car seals
Compression diaphragms	Regulator diaphragms
Control diaphragms	Soundproofing
Fuel containers	Transmission seals
Fuel pump diaphragms	Vacuum pump diaphragms
Gaskets	Vapor barriers
Instrument diaphragms	Vapor conservation balloons

Ventilating tubing

... the one complete source of engineered industrial coated fabrics

Whether it's resistance to high temperature, oil or abrasion — or flexibility at low temperature or room temperature, there's a Reevecote designed to do your job.

96 different Reevecote styles are in stock at all times! Constructed under rigid quality-control standards, each is guaranteed to meet the exact listed specifications.

In addition, full research and development facilities are available for new applications, backed by the skills and knowledge of fabrics and coatings that only the combination of Reeves and Vulcan can supply. Whatever your requirements, specify Reevecote and be sure.

Write for a copy of the new Reevecote catalog—it's just off the press.

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Please send me a copy of your new REEVECOTE catalog.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

For more information, turn to Reader Service card, circle No. 466

Improved but unused materials

To the Editor:

There is something happening today that I don't quite understand. Your excellent magazine provides up-to-date coverage of many new materials that are available. Yet few firms seem to be taking advantage of these materials.

To cite one small example, an ad on p 32 of your Dec '58 issue points out a method which provides improved corrosion resistance for chromium plate. I bought a '59 car a few months ago and already the chrome is becoming pitted, even though the car is receiving the best of care. It's quite irritating to see this happen. Here is only one of many areas where new materials and processes apparently go unused for many years.

RICHARD PAULSON
La Jolla, Calif.

Perforated article pages

To the Editor:

Having been a subscriber to your magazine for the past six years, I find the subjects covered of great interest, not only from the standpoint of information helpful in procurement, but because many items published should prove of great value to our design engineering department.

We have a large and diversified engineering staff and it would be most helpful if the articles covering properties of materials and their possible application were printed so as to allow for ready tear out by perforations along the binding line. We refer you to *Aeronautical Purchasing* magazine as an example. Further, it would be most helpful to the writer, and I am sure to others, if your company would issue, from time to time, a topical and cross reference index of the items appearing in your magazine.

J. A. ALLES
Director of Purchases
Emerson Electric Mfg. Co.

We are aware of the desirability of perforating the pages, and we investigated this matter thoroughly only to come to the conclusion that the additional cost could not be justified at the present time. We do publish a semi-annual index in the magazine. We hope sometime in the future to develop five-year indexes.

Hard surfacing alloys

To the Editor:

In making a comparison chart of hard surfacing alloys, File Facts, Dec '59, you omitted one very basic material which is usually described as nickel-chromium-boron alloy. Produced by several manufacturers today, it was first produced solely by Wall

TAKES OFF ITS HAT TO NOBODY!

Machine, lag, and carriage bolts.
All sizes. Quick delivery from stock.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export distributor: Bethlehem Steel Export Corporation.

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 459

General view of the wet laboratory

Put WAUKESHA FOUNDRY on Your VALUE ANALYSIS Team for Corrosion Resistant Castings

One phase of Value Analysis is group skill in determining how a presently satisfactory component can be made better with a saving in cost.

In the alloy castings field, WAUKESHA often serves as a member of a manufacturer's Value Analysis Team. With one of the finest metallurgical testing and research laboratories manned by scientists who are eminent in their field, WAUKESHA can and does contribute importantly to the group effort of "making it better and lower in final cost."

Often questions concerning castings and the metallurgical problems involved can be answered readily by virtue of WAUKESHA'S depth of experience. More often the answer will be found in WAUKESHA'S Laboratory . . . In any event, call us in. You find us an invaluable member of your team in

The carbon analyzer

"developing your castings from the blue print to the finished component."

Waukesha
FOUNDRY COMPANY
5904 Lincoln Avenue
Waukesha, Wisconsin

WAUKESHA FOUNDRY COMPANY
Waukesha, Wisconsin

Gentlemen:

☐ I would like to have a letter giving detailed information about Waukesha's foundry and metallurgical research facilities

☐ I would like to have your field technician call.

NAME .....
TITLE .....
FIRM .....
ADDRESS .....
CITY ..... STATE 8013

For more information, turn to Reader Service card, circle No. 512

Colmonoy Corp. They marketed it under several "number" designations, according to the amount of chromium and boron alloyed with the nickel base. The best known of these variations is Colmonoy No. 6 alloy.

WALTER HEMSING
A. Hemsing, Advertising
Detroit, Mich.

Unfortunately our source material failed to mention the alloy.

Coated copper alloy

To the Editor:

At present I am conducting an investigation regarding a new method of color coating the items in one of our lines. The color coating is used for identification only, but it must be corrosion resistant. It is desired to precoat the material before manufacturing although it is subjected to several stages such as blanking, cupping and drawing. The materials involved could be either copper or brass.

I would appreciate any information you may have regarding this subject.

LEONARD KNABLIN
Burndy Corp.
Omaton Div.,
Norwalk, Conn.

We suggest a chemical conversion coating such as the chromate coating supplied by Allied Research Products, Inc., 4004 E. Monument St., Baltimore 5, Md.

Stainless steel 319

To the Editor:

Congratulations on the fine manual on stainless steels, Jan '59. You might have mentioned the new experimental type 319 which may be specified in place of type 316 and which has more resistance to chemical corrosion. The most recent information indicates it has the same stress values as 316.

NED F. MORRIS
Cincinnati, Ohio

We hope to publish more information on type 319 in a forthcoming issue.

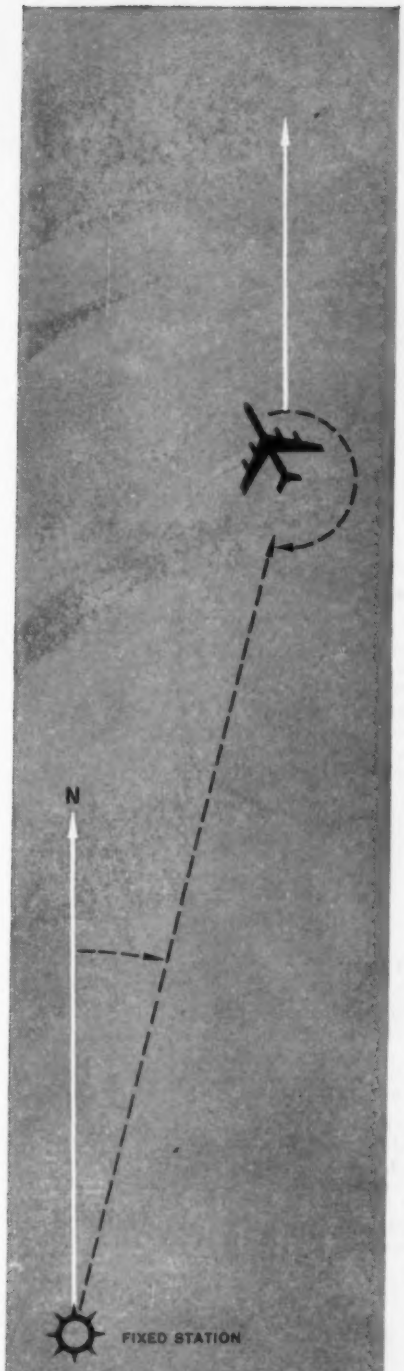
Magnetic rubber

To the Editor:

Regarding a letter of inquiry in the February issue, Denmag magnetic rubber is manufactured by Denman Rubber Co., Warren, Ohio.

W. P. GRILLET
E. I. du Pont de Nemours & Co.
Pompton Lakes, N. J.

This information was also supplied by H. W. Williams, National U. S. Radiator Corp. and Louis R. Zehnder.



MYCALEX® 410 glass-bonded mica

the world's most nearly perfect precision-molded electronic insulation

"gives high impact strength . . . superior insulating value," in ITT's TACAN beacon

Latest achievement in air navigation and traffic control is TACAN, an advanced radio air navigation system developed by ITT LABORATORIES, DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, for the U. S. Navy and Air Force.

Prominently featured in the 12 KV discharge switch of TACAN's ground beacon transmitter is MYCALEX 410 glass-bonded mica insulation. Here and in other applications, this precision-molded insulation shows exceptional mechanical strength and superior electrical resistance. It will withstand operating temperatures to +600°F . . . and has *total dimensional stability!*

Why was MYCALEX designed into this item? Says ITT: "*MYCALEX was selected because of its high impact strength and excellent insulating properties, which we found to be as good as or better than grade L-4B in ceramic. In addition, the good molding properties of MYCALEX made it possible to design the insulator with convolutions which increased the creepage path to ground.*"

MYCALEX 410 is one of a wide variety of glass-bonded mica and ceramoplastic insulation materials created and perfected by MYCALEX CORPORATION OF AMERICA. Whatever insulation characteristics you require, there is a MYCALEX material to meet your need. For example, SUPRAMICA® 560 precision-molded ceramoplastic offers a maximum operating temperature of +932°F . . . and SUPRAMICA 620 machinable ceramoplastic offers a maximum operating temperature of +1550°F. Write today for specifics.

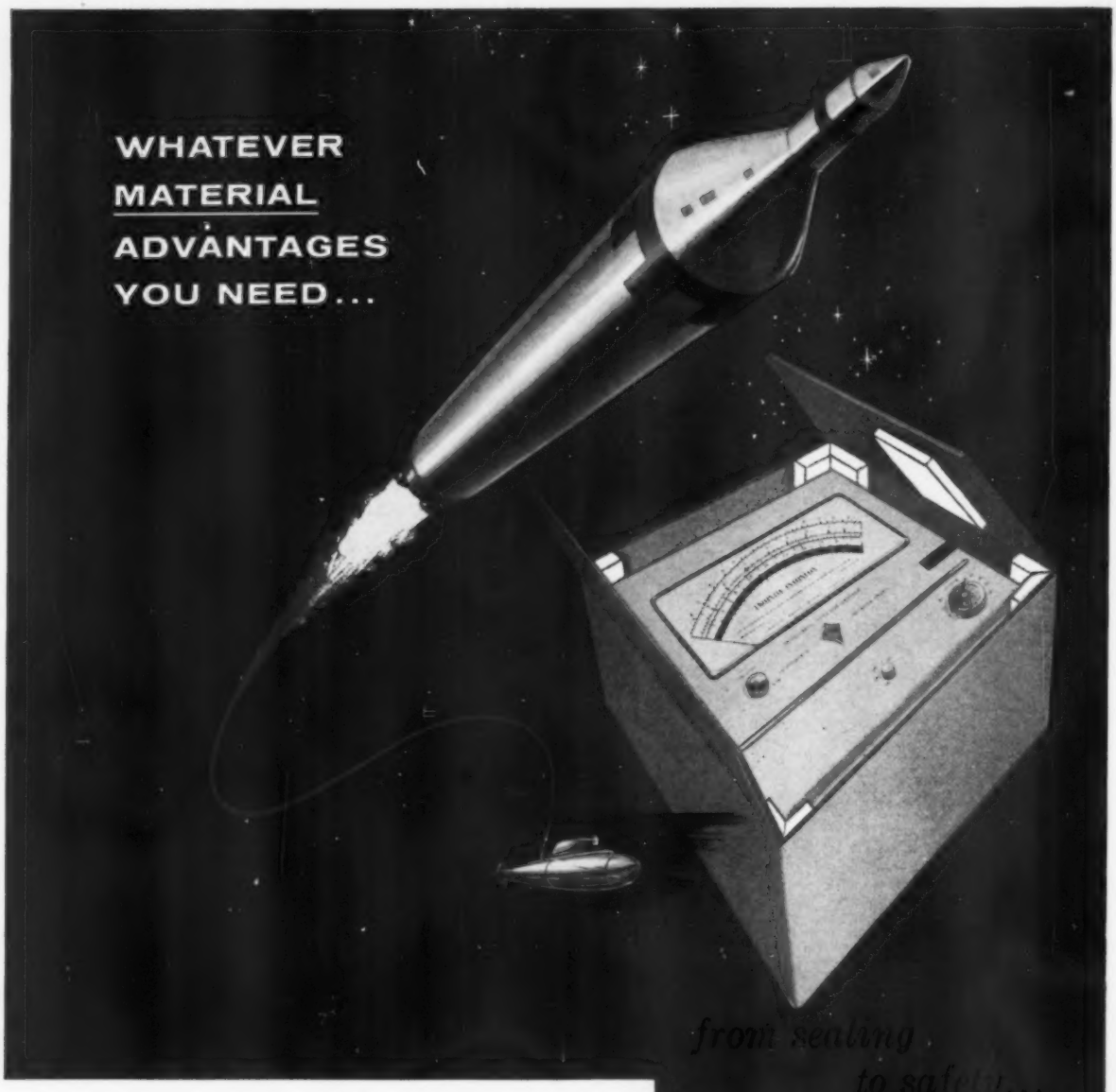
General Offices and Plant: 122-F Clifton Blvd., Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

SYNTHAMICA® SYNTHETIC MICA · SUPRAMICA® CERAMOPLASTIC · SINCE 1919 MYCALEX® MICA-INSULATED

MYCALEX
CORPORATION OF AMERICA

WORLD'S LARGEST MANUFACTURER OF GLASS-BONDED MICA AND CERAMOPLASTIC PRODUCTS

For more information, turn to Reader Service card, circle No. 516



Versatile A+ FELTS . . . *precision engineered* to meet your *exact* design specifications . . . have over a thousand different uses. They form the tight-sealing packing and gaskets essential to reliable missile performance . . . and insure the safe shipment of delicate instruments by cushioning them against shock and vibration. In other forms, they filter . . . insulate . . . polish . . . absorb . . . and set new standards in fashion.

Find out how A+ Felts can improve *your* application by sending us your design problem. Our engineers will follow through promptly. Write: Engineering Dept., American Felt Company, 408 Glenville Road, Glenville, Conn.

Among our famous trademarks: **VISTEX**—fiber-reinforced gaskets and seals; **WINDSOR FELT**—nonwoven bonded fabrics; **HUSHALON**—decorative and acoustical wall covering.

YOU'LL FIND THEM IN A plus FELTS!

American Felt Company

For more information, turn to Reader Service card, circle No. 506

PRICES AND SUPPLY

...AT A GLANCE

Polycarbonate plastics will be commercially available toward the end of 1960—the scheduled completion date of General Electric Co.'s new plant. Production capacity of the new plant has not been disclosed; however, industry sources guess at a minimum production of 5 million pounds per year. The new material is now available in limited quantities at a price of $2.35-2.75 per lb.

Price of tantalum has been cut $25 per lb by Union Carbide Metals Co., Div. of Union Carbide Corp. New price is $35 per lb.

There is more than enough mica available to satisfy all demands, according to the Mica Industry Assn., Inc. The material has erroneously been considered scarce.

Polypropylene should become more easily available within the next year or two when there will be five major U. S. producers. The two latest entries are Montecatini, Inc. (which has just announced plans for its first U. S. plant) and Texas Eastman Co. Present and expected polypropylene capacity (in millions of pounds) is now: 1) Hercules Powder Co., now 20, to go up to 50; 2) AviSun Corp., now 10, to go up to 20; 3) Humble Oil Co., 40 in early 1960; 4) Texas Eastman, pilot plant; and 5) Montecatini, initially 11.

Titanium prices have been cut by Du Pont. New prices are: A-1 Grade sponge $1.60 per lb, down from $1.82; and A-2 Grade sponge $1.50, down from $1.70.

Price of silicone rubber has been reduced by Dow Corning Corp. The reduction, the fourth since the material's introduction in 1956, brings the price down to $16 per lb.

Aluminum production will set a new record in 1959, according to R. E. Reynolds, Jr. The president of Reynolds Metals Co. says, primary output should reach 1.9 million tons, or 13% higher than the record 1.7 million tons produced in 1956.

Prices have been cut on chlorinated polyether, Hercules Powder Co.'s new corrosion resistant thermoplastic. The material is now commercially available at the following prices: natural, $3.50 per lb, and olive drab and black, $3.75 per lb, both down from $6 per lb.

Use of plastics in sheet forming will increase by 10% in 1959, according to Robert Kitteridge, chairman of the Sheet Forming Div., Society of the Plastics Industry, Inc. The increase will boost raw materials consumption by about 15 million pounds.

Increased availability of polyvinyl acetate emulsions and butadiene-styrene latex will result from a new plant built by Dewey and Almy Chemical Div., W. R. Grace & Co. According to the company, the new plant will have a total capacity of 20 million pounds per year.

Larger extruded aluminum shapes will be available as a result of a new 5200-ton press installed by Aluminum Co. of America. According to Alcoa, the new press will produce aluminum shapes with cross sections up to 34 sq in.

What is zinc?

zinc (zink, *n.* [G. *zink*, prob. akin to *zinn* tin: cf. F. *zinc*, fr. G. Cf. TIN.] 1. *Chem.* A bluish white crystalline metallic element, brittle when cold, malleable at 120-150° C. (250-300° F.), and very brittle at 200° C. It is practically unaffected by air and moisture at ordinary temperatures. Symbol, *Zn*; at. wt., 65.37. Zinc melts at 420° C. (788° F.). At about 930° C. it boils, yielding vapors which burn in air, forming the oxide. Sp. gr. of zinc, 7-7.2. Weight of a cubic foot, 437-450 lbs.

In commerce there is a lot more to zinc than this simple definition. First, there are 6 different ASTM Specifications. Then, within various industries, there are innumerable "Custom" grades made to the consumer's *own* specifications.

Thus, the most important factor in Zinc Production is St. Joe's metallurgical control.

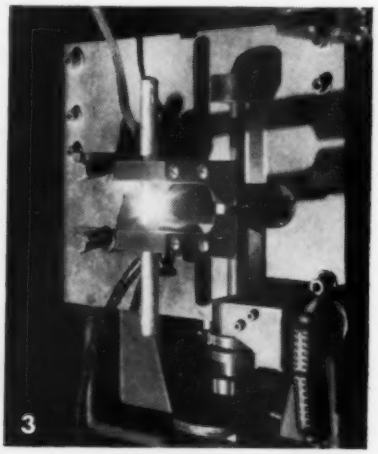
HERE IS HOW IT'S DONE AT OUR JOSEPHTOWN,

This is the final production stage of St. Joe Electrothermic zinc — a continuous vacuum-type condenser. There are eleven of them, each serving a casting bench. These furnaces are tapped every 20 minutes and from each, 1400 lbs. of zinc, perhaps part of your order, flows into the ladle. The operator using a small hand ladle casts two samples (insert shows samples approx. 1/5 actual size) and sends them via a Lamson Airtube System to . . .

. . . the Baird Direct Reading Spectrometer Lab. There the samples' sprues are removed, the ends chamferred and automatically machined to precise dimensions; they are now test electrodes 3" long that look like this:

A lab technician places the two samples in the Spectrometer's electrode holders, closes the door and merely pushes a button.

Extremely high voltage creates an arc across the electrodes. As elements are vaporized, light from the arc is broken into element lines of varying light energy. This energy, directed to photomultipliers (photo-sensitive electronic tubes), is converted to electrical energy which actuates . . .



ST. JOSEPH LEAD COMPANY

ST. JOE

250 PARK AVENUE
NEW YORK 17, N. Y.

ZN-136

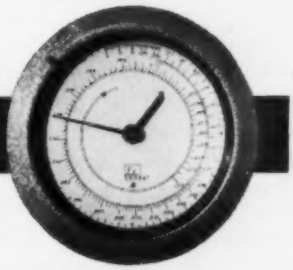
St. Joe can practically guarantee that once we have "tailor-made" a metal to your own specifications, we can supply you with carload after carload of zinc, unchanging in analysis. This *consistent* control of grade is one of several reasons why the records of our shipments of zinc to continuous galvanizers reads like a "Who's Who" of that industry.

When critical alloying specifications are being maintained on continuous slab casting, a sample analysis can be taken from each tap and composition confirmed *before* the zinc becomes too cold to pour.

WE ACCOMPLISH THIS BY A METHOD OF HIGH-SPEED ZINC ANALYSIS

Using a Baird-Atomic Direct Reading Spectrometer, St. Joe HAS SLASHED ANALYSIS TIME TO LESS THAN 10 MINUTES . . . *WITH A COMPLETE QUANTITATIVE REPORT ON 10 ELEMENTS!*

PA., ZINC SMELTER



. . . pre-calibrated dials that indicate elements **directly IN PERCENTAGES!** In five minutes the zinc sample can be completely analyzed for iron, lead, cadmium, copper, aluminum, indium, tin, antimony, silicon and magnesium. Two minutes later by return tube . . .

4

. . . casting room operators have the complete analysis. They know whether or not critical specifications are being maintained. **TOTAL ELAPSED TIME FROM COLLECTION OF SAMPLE TO COMPOSITION REPORT — LESS THAN 10 MINUTES!**

6

5

ST. JOE Electro-Thermic ZINC

HIGH GRADE
INTERMEDIATE
BRASS SPECIAL
PRIME WESTERN

For more information, turn to Reader Service card, circle No. 458

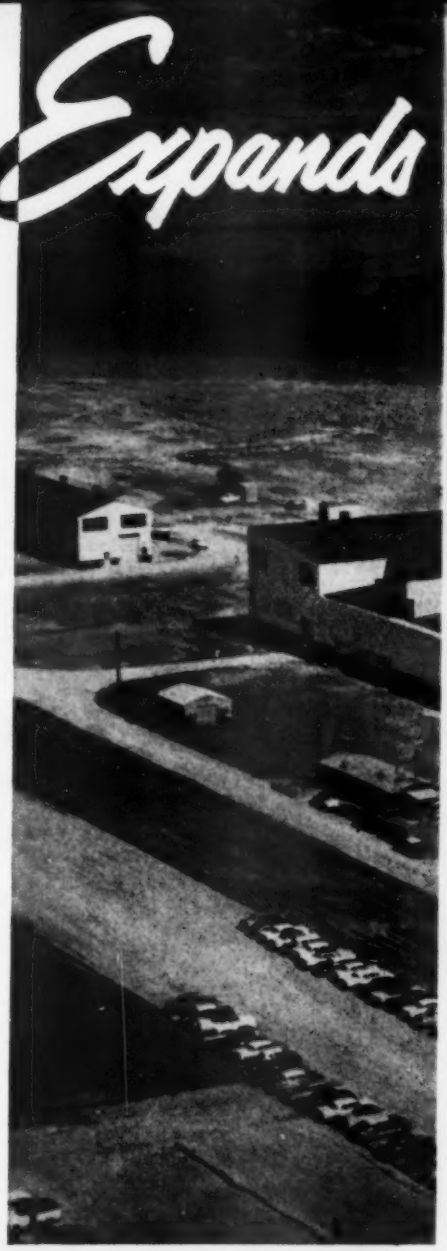
UNIVERSAL-CYCLOPS STEEL *Expands*

. . . with a New Plant and New Cold Finishing Facilities at Coshocton, Ohio

Universal-Cyclops, one of the leading producers of cold rolled stainless steel strip, announces the opening of a new plant at Coshocton, Ohio, which will supplement our facilities at Bridgeville, Pa., and greatly augment production capacity to meet the ever-increasing demands for UNILOY® Stainless Steel.

Completely new, this modern plant represents a major step in our corporate expansion program. It provides the finest facilities, production skills, engineering and metallurgical experience. It conforms to the policies maintained throughout our 75 year history, to constantly strive for highest quality standards in our products.

Customer oriented throughout, personnel and equipment are geared to meet the needs of our customers. Large stocks of finished coils are maintained at all times for prompt delivery.



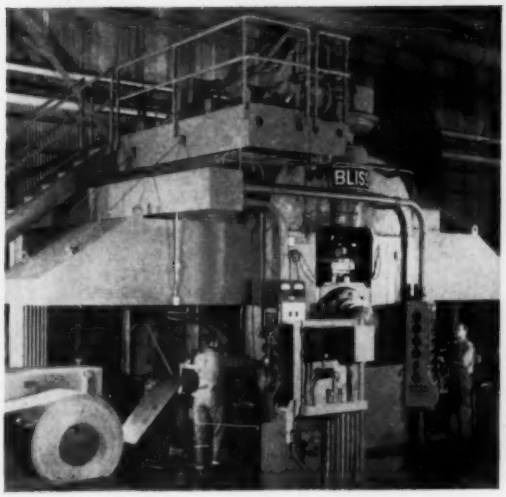
UNIVERSAL CYCLOPS
UC STEEL
STEEL CORPORATION
Bridgeville, Pa.

For more information, circle No. 429

STAINLESS STEELS
TOOL STEELS · HIGH TEMPERATURE METALS

The most modern annealing and pickling line in the industry—over 600 ft. long. Handles two coils up to 24″ width.

Stainless Strip Capacity



Modern four-high cold rolling mill.

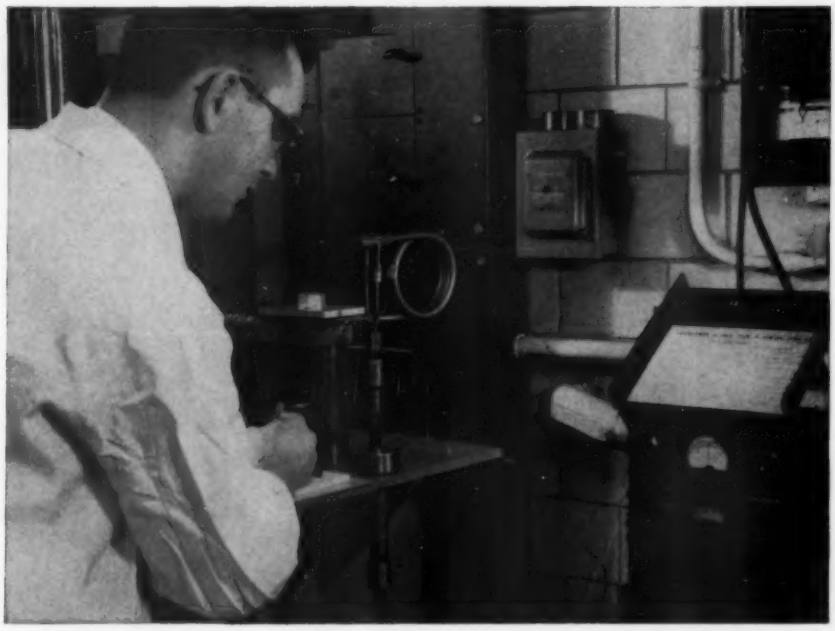
Temper mill provides top quality finish.

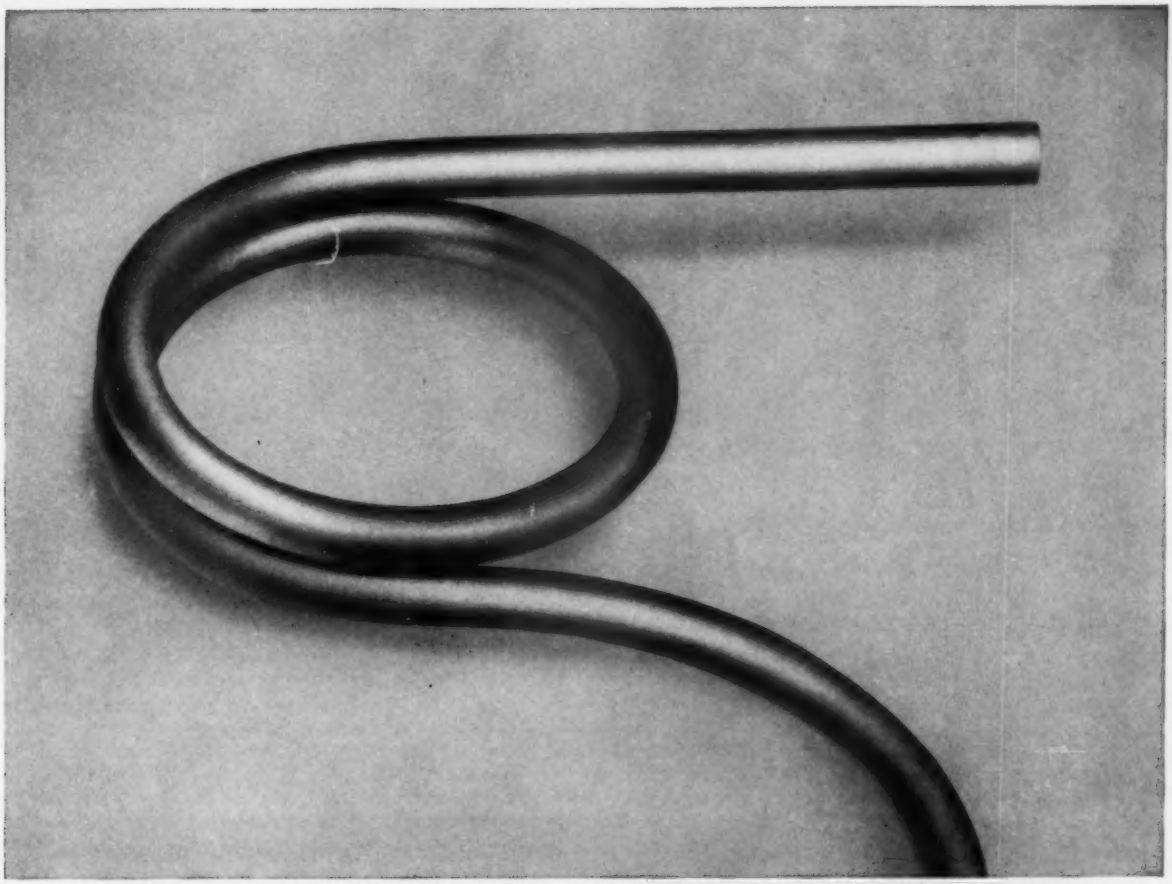
Large stocks of stainless stee coils—assure prompt deliver

20,000 chairs rock on USS American Springs without one failure

...thanks to AS&W

In the American Steel & Wire Spring Testing Laboratory, the springs recommended for the Homecrest Chair go through extensive tests. This Fatigue machine, by means of strain-gauge verification, simulates years of use in a relatively short testing time.





Here is the spring recommended by American Steel & Wire for use in this chair. To supplement the AS&W tests, the Homecrest Company subjected these springs to a simulated rocking test. Under a weight of 250 pounds, these springs were rocked 750,000 times, without failure.

Spring Engineering Research Service

The Homecrest Company, Wadena, Minnesota, wanted to add a swivel rocking chair to their line of modern, functional home furniture. However, they would produce this chair only if it could be a quality item that would give good, dependable service. While designing the chair, they checked with the American Steel & Wire Spring Engineering Consulting Service. The engineers studied the problem, ran extensive tests and finally recommended a pair of round wire helical single coil torsion springs. Using these springs, Homecrest designed, fabricated and marketed the chair. Today 20,000 of these chairs have been sold and not one failure of an AS&W Spring has been reported.

Mr. A. L. Englemann, a partner of Homecrest Company, says, "We have purchased from American Steel & Wire over 45,000 springs, and not one has been reported a failure. We couldn't be happier with American Steel & Wire as a supply source for our springs."

If you have a spring problem, or would like advice on the use of springs in your product, get in touch with any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels, from steel chemistry through product application, to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.*

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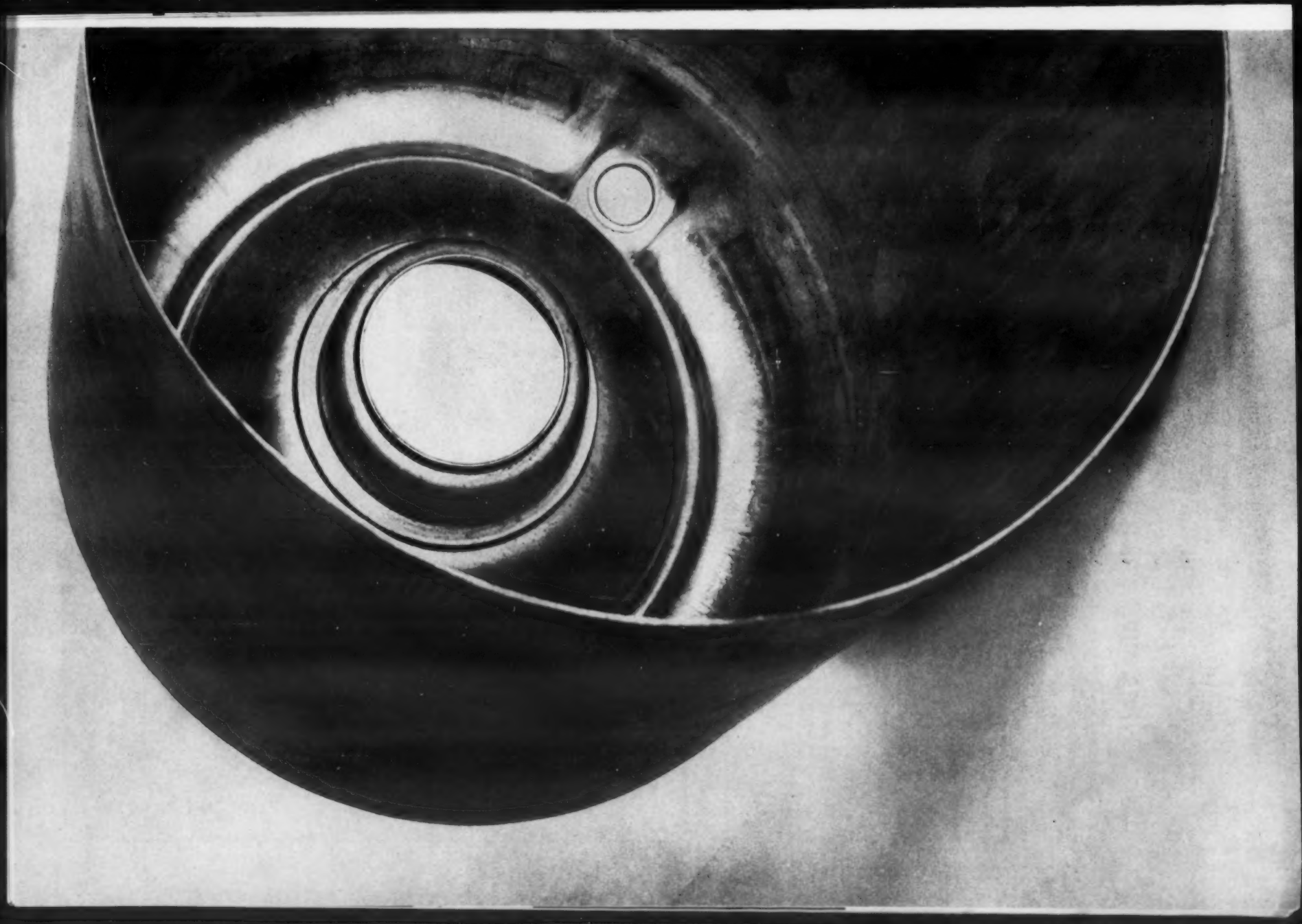

Deep-Forming USS Galvanized Steel Sheets **and the zinc stays on**

The body and breast of this pressure spray tank is fabricated from one piece of 24-gage Galvanized Steel Sheet. A 20" circle blank is cut from the sheet. It is drawn 6½" deep and then reverse drawn to 11¾" deep by 7¾" wide—the finished size of the tank.

Standard Container, Inc., of Rockaway, New Jersey, selected USS Galvanized Steel for the tank because during the forming and punching operations, the zinc does not flake off the base metal. This remarkable adherence of zinc comes from the hot dip process of coating USS Galvanized Steel. The process makes a bond between zinc and base metal that is virtually inseparable. This, and the fine ductility of USS Galvanized Steel Sheets make them ideal for severe fabrication.

Give your product the added quality provided by USS Galvanized Steel Sheets. Contact your local U.S. Steel Sales Office or the steel warehouse serving your area.

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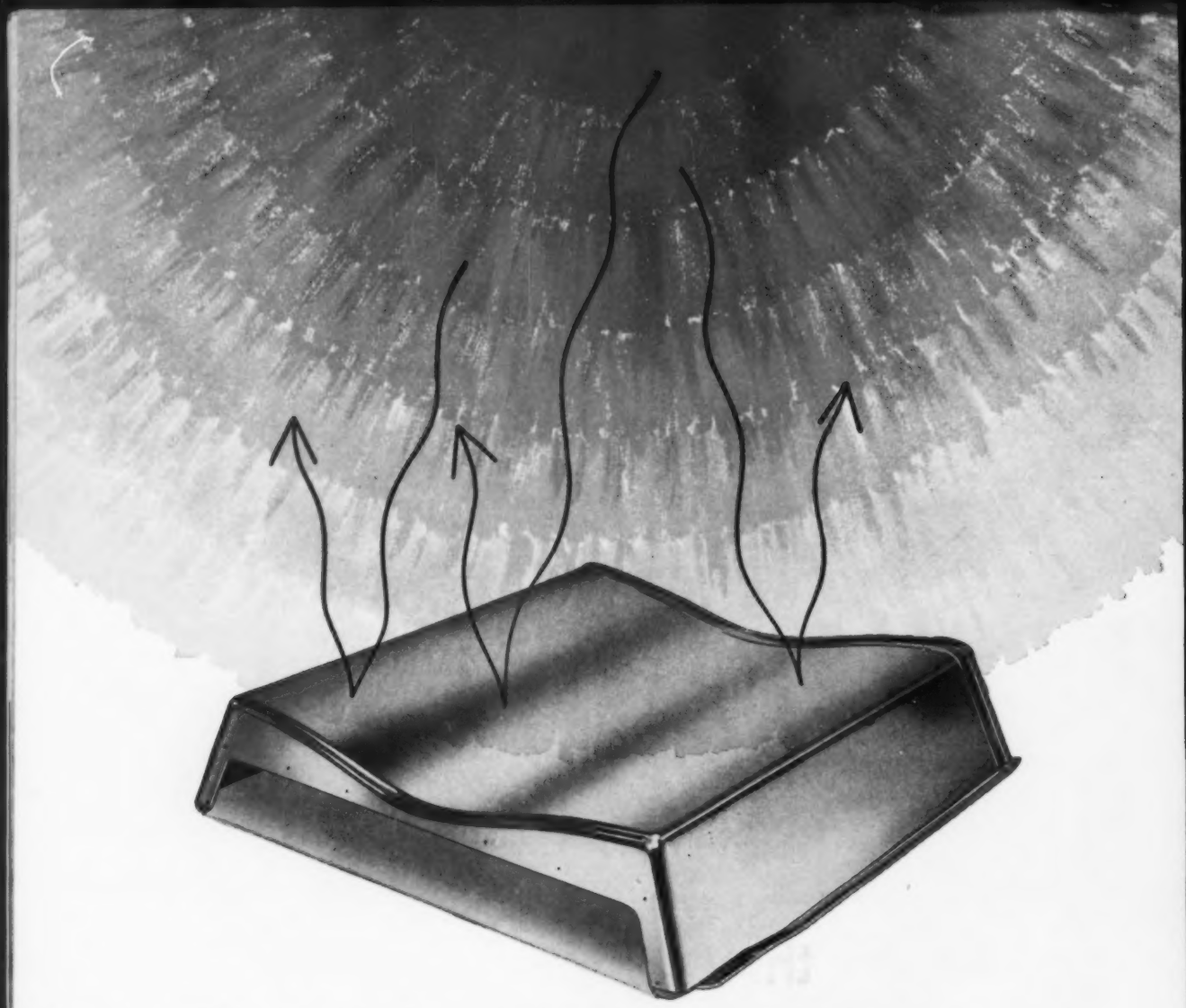
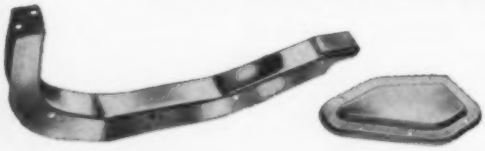
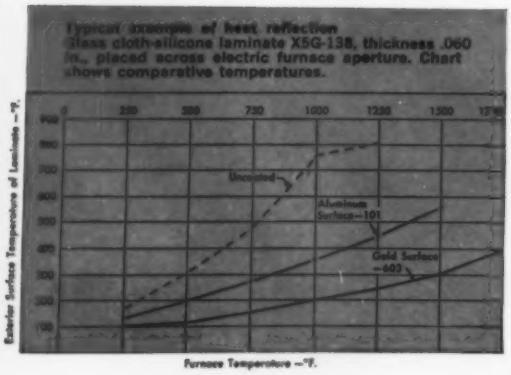


Now, reflect up to 1750°F radiant heat from SWEDLOW metallized laminates




Typical example of heat reflection. Glass cloth-silicone laminate X5G-138, thickness .060 in., placed across electric furnace aperture. Chart shows comparative temperatures.
Exterior Surface Temperature of Laminate —°F.
Furnace Temperature —°F.
Uncoated
Aluminum Surface—101
Gold Surface —603

Compound shapes—minimum weight and bulk—highly efficient reflectivity—distinguish these materials and solve the problem of resistance to elevated temperatures.

Swedlow's solution for light weight heat protection problems uses a base of fiberglass fillers. To these are added any of an impressive variety of silicone, phenolic, epoxy, TAC polyester or polyester binders to meet specific service conditions. The resulting high-strength laminate is furnished flat or molded to any contour desired. Metallic coatings then further increase heat reflectivity and resistance. Swedlow-pioneered Type -101 aluminum coating is now in wide use for the 200°F to 1400°F range. The more recently developed Type -603 gold now raises the limit to approximately 1750°F.

Swedlow research is continuing the development of many combinations for the growing variety of aircraft, missile and electronic applications. To learn how these new materials can help solve your heat problems, contact the Swedlow plant nearest you. Or send for new literature—"Radiant Heat Reflective Laminates." Please refer to Dept. 18.

SWEDLOW Inc.
Formerly Swedlow Plastics Company

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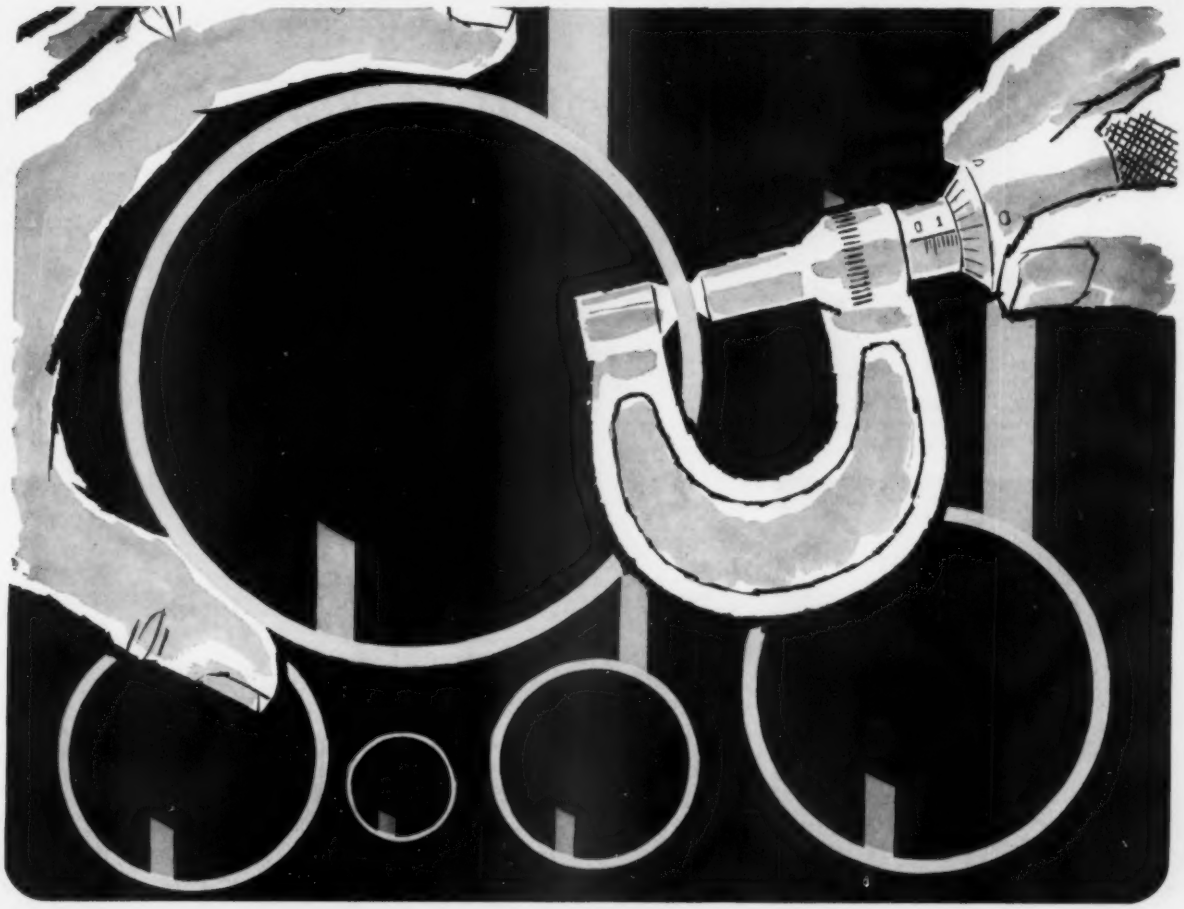
Experience — *the added alloy in* ***Allegheny Stainless***



looking for thin walls in big diameters?

A-L now offers a wide range of stainless seamless tubing with walls as thin as .013".

From what other source would you expect to get stainless seamless tubing of 3½" OD with walls as thin as .058" and in the widest range of materials anywhere to fit a broad range of requirements in new products and processes?

Allegheny Stainless Tubing ranges from ⅜" OD to 3½" OD with wall thickness from .013" to .375". Typical of the specials A-L can make are 2½" OD—.032" wall thickness, 3" OD—.042" wall thickness and 3½" OD—.058" wall thickness. All sizes with true circularity, no dents or handling marks.

Stainless seamless tubing is made in all stainless grades including 309, 317, 318, 310, 416 and 446—normally difficult to obtain. For special high-temperature applications, A-L produces tubing in high-strength alloys such as A-286, and in vacuum melted steels and alloys. Also in custom analyses such as low cobalt (.01-.05) grades and with boron additions to standard grades.

A-L also makes composite tubes with bonded combinations of carbon and stainless steels and other metals for unusual corrosion applications in process equipment.

Allegheny Ludlum Tubing is available in small orders in random or cut lengths. Standard grades in stock throughout the country.

Write for your copy of Allegheny Ludlum Stainless Tubing, or call your A-L representative for all the help you need. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MM-20.***

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Francis E. Blod specifies

Sharonart*

for the kitchen of tomorrow . . .

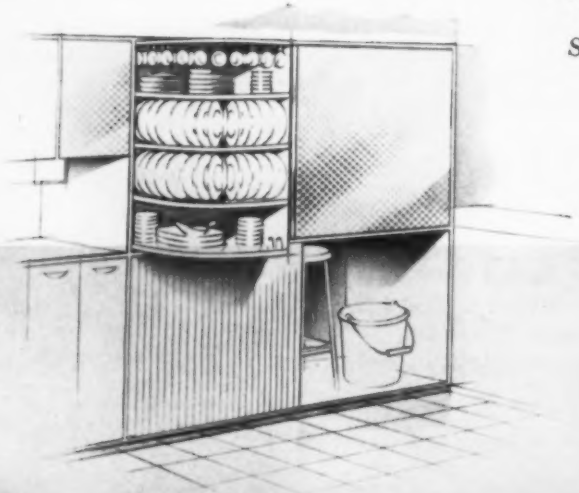
To give kitchen storage added utility and exciting style that blends with modern day kitchen appliances, nationally known industrial designer Francis Blod has taken advantage of Sharonart, to achieve the clean line, functional and highly attractive kitchen storage unit shown on these pages.*

A recipient of many national design awards, Mr. Blod is a Board Member and President Emeritus of the Package Designers Council; graduate and member of the Board of Trustees of the School of Design of Pratt Institute.

Sharonart*, Sharon's exciting new surface patterned steel, is stimulating the imaginations of leading designers everywhere.

It has all the strength, economy and forming advantages of steel, plus the mar resistance and added beauty of a textured surface. Ideal for wear areas, it permits model changing without retooling. Available in dozens of patterns, Sharonart* can be made in almost any special pattern to suit design requirements. Patterns are rolled in plain carbon steel or in stainless steel. Literature and samples available upon request from the Sharon representative in your area by writing direct to the *Sharon Steel Corporation, Sharon, Pa.*

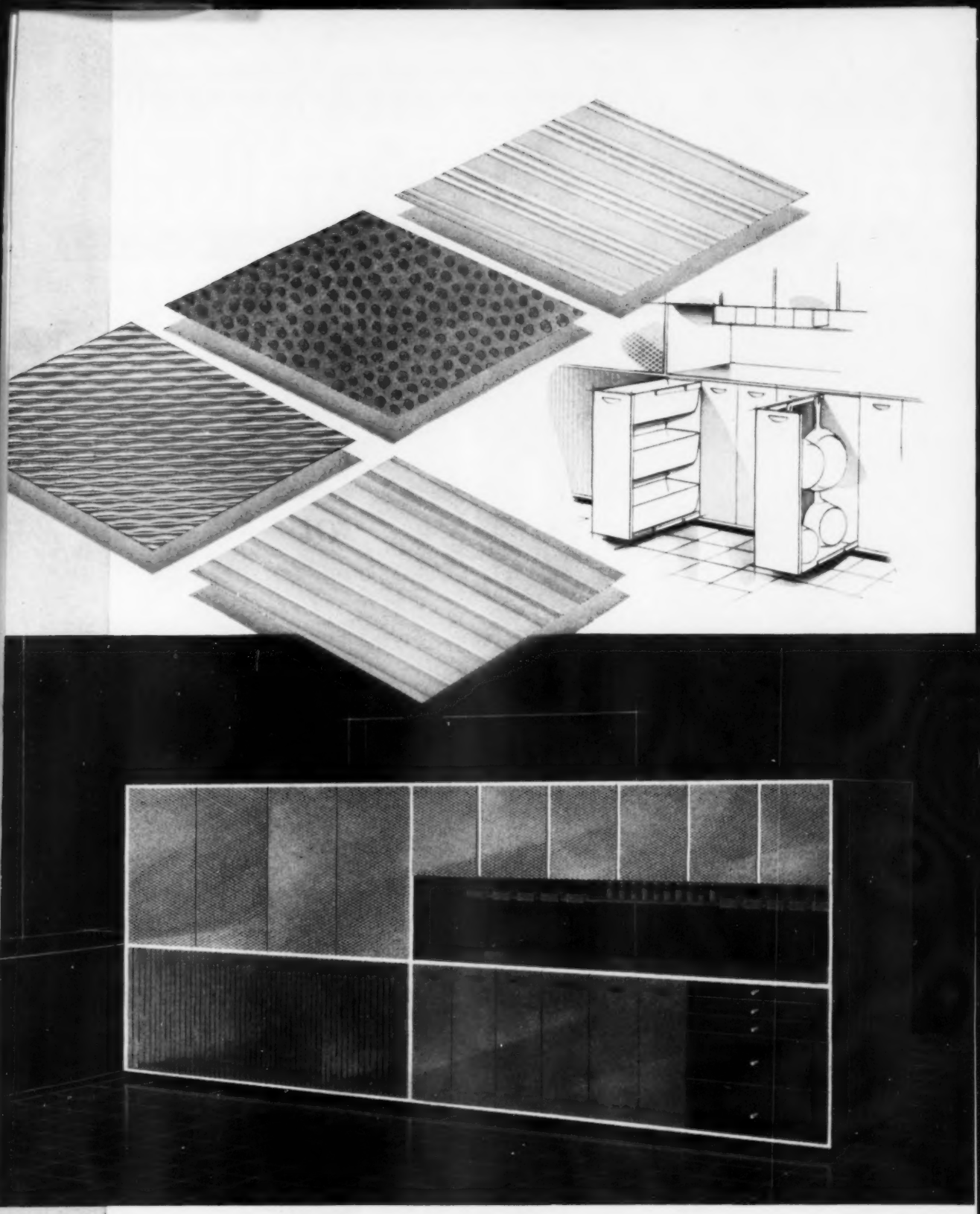
*TM



Rotating cupboard accomodates both dishes and glassware providing organization and ready access while preventing chipping. Sliding Sharonart panel utility section provides storage for outsized objects.*

Pull-out bins offer ready accessibility to staple vegetables as well as pots and pans. Protruding handles are eliminated through the use of pressure sensitive spring loaded closures and recessed pulls.

Trim look of Blod designed kitchen unit includes flatware and linen drawers and automatic Sharonart stainless steel cannisters adjusted to dispense premeasured amounts of dry foods, spices, etc.*



SHARON *Quality* **STEEL** SHARONSTEEL

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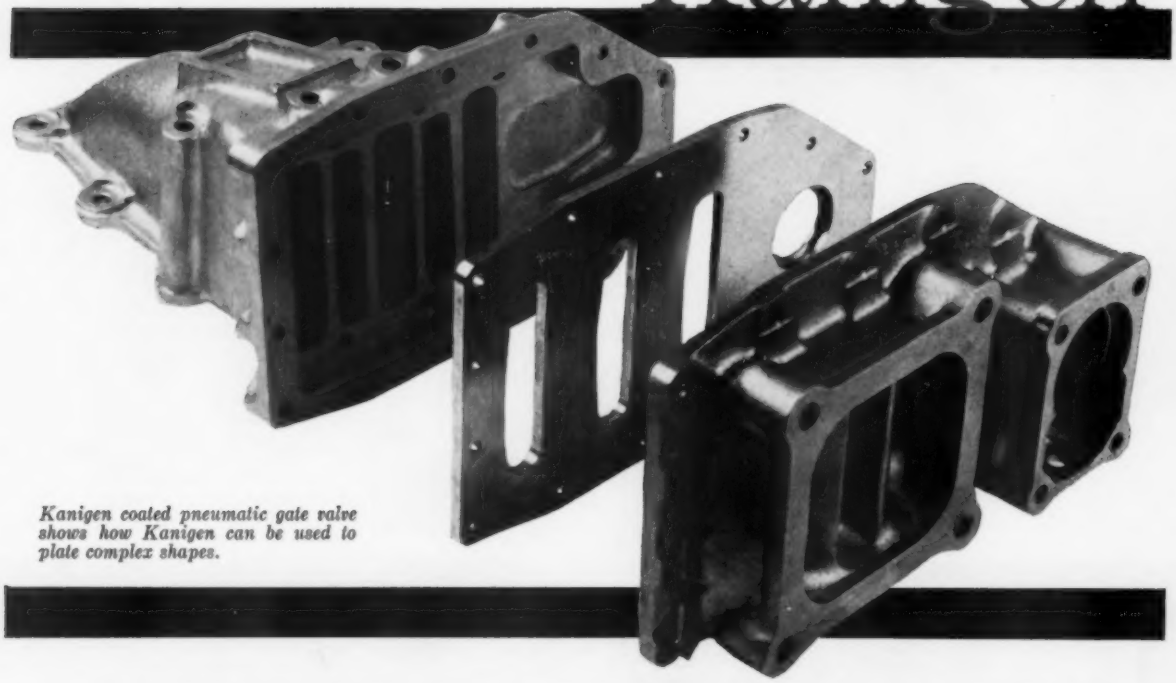
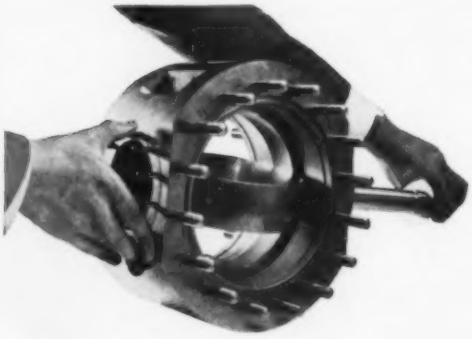


Kanigen coated pneumatic gate valve shows how Kanigen can be used to plate complex shapes.

KANIGEN is a chemically and metallurgically unique process that provides an extremely uniform, hard, corrosion and abrasion-resistant nickel alloy surface on most metals. You obtain practically the same end result with inexpensive, easily machined and fabricated materials that you do with expensive, difficult-to-work alloys. Where weight is a factor, **KANIGEN**-coated aluminum and aluminum alloys offer great advantages.



Butterfly valve assembly, Kanigen-coated for corrosion and abrasion resistance.

General American offers **KANIGEN** at Sharon, Pennsylvania; East Chicago, Indiana, and Compton, California and from licensees. Large production facilities for the plating of **KANIGEN** on iron, aluminum, copper, titanium and their alloys are available. Pilot-scale facilities for plating magnesium, beryllium, uranium, plastics and ceramics are maintained at our laboratory. For further information, call or write. You'll find *it pays to plan with General American.*

KANIGEN is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

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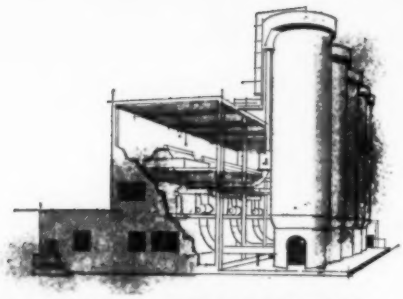

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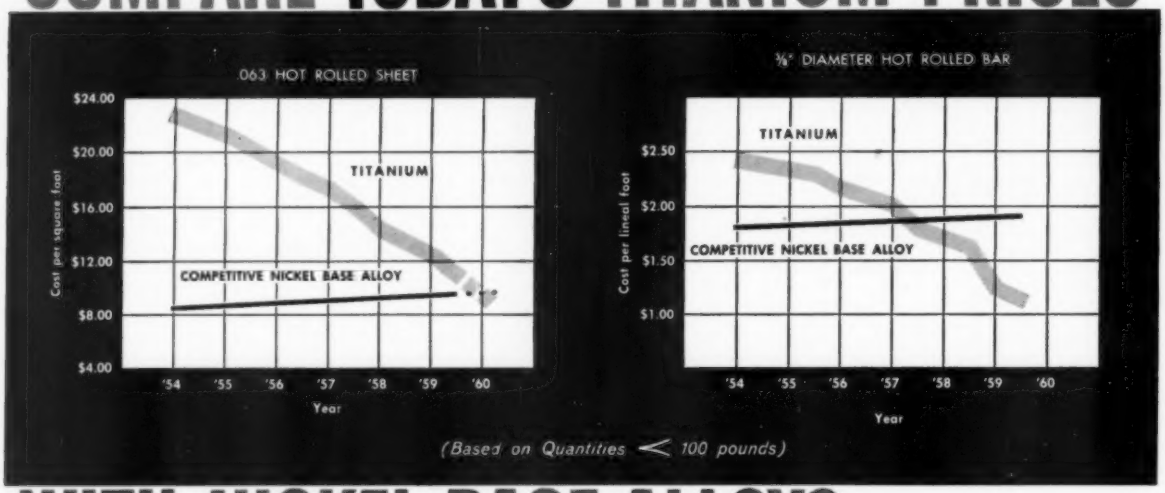

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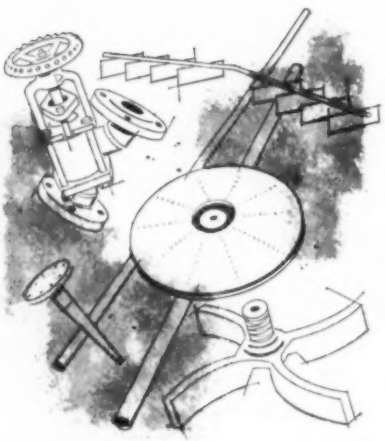

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361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390
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23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110
111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154
155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198
199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242
243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264
265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286
287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308
309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330
331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352
353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374
375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396
397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418
419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462
463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484
485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506
507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528
529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550
551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572
573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594
595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616
617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638
639	640	641	642	643	644	645	646	647	648	649	650										

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PAGE NOS.

Adhesives 136, 212
Aluminum and its alloys..... 130, 155, 207
Anodes 66-67, 81

Bearings 138
Bimetals, thermostatic ..70-71, 196
Bismuth and its alloys 211

Carbon, graphite 147, 170
Casting alloys 45, 48, 200
Castings
Centrifugal 178
Continuous 186
Die 45-48, 153, 194
Investment 207
Permanent mold 159
Sand 159, 160, 167, 207
Shell mold 140
Cellular materials 6
Ceramics 66
Clad metals 78
Clamps, cable 203
Coatings
Chemical conversion 82-83, 180, 205
Diffusion 146
Electroless nickel 32
Metallic 32, 49, 70-71, 144, 146, 200
Metallized 177
Plastisol 208
Contact materials, electrical .. 78
Copper and its alloys..inside front cover, 81

Dies, custom 203
Drawn shapes 181, 201

Extrusions, metallic 130, 212
Extrusions, nonmetallic 9

PAGE NOS.

Fabrics, coated 19
Fasteners, mechanical 15, 64, 80, 185, 202, 204
Felts 18
Ferroalloys 189
Finishing machines 159
Flame cutting 88
Foam, urethane 77, 182, 204
Forgings .....inside front cover, 139, 187

Gaskets 201
Glass 156, 161, 168

Heating, induction 203
High temperature materials... 28, 165, 179
Honeycomb materials 56

Indium and its alloys 153
Insulation 17, 79
Iron, alloy 160

Laminates
Metallized 28
Metal-plastic 169, 172
Metal-wood 188
Plastics 44, 68, 162
Lead and its alloys 209
Lining materials 164
Low melting alloys 211

Metal powder parts 138
Metal powders 86-87
Mica, glass-bonded 17
Moldings, plastics 195, 208, 210
Moldings, rubber 175, 211

Nickel and its alloys 2, 165

O-rings, nonmetallic 201

Packings 201
Pencils, drawing 159
Plastics (distributors) 201
Plastics materials
ABS 135
Epoxies 8
Fluorocarbons 152, 164
Phenolics 73
Polyester film 199
Polyesters 13

PAGE NOS.

Polyethylenes 84-85, 163
Polyvinyl chloride 5
Urea 74-75
Plastics, reinforced 210
Plating chemicals 66-67
Platinum and platinum group alloys 58-59
Precision parts, metal 174
Precoated & preplated metals..26-27, 45-48, 49, 52

Quartz, fused 70-71

Refractory materials 72
Resistance alloys 148
Rivets, tubular 202
Rubber, silicone 143
Rubber, synthetic ....33, 65, inside back cover, 141, 190

Seals 18, 150
Self-adhesive materials 153
Silicones 127-128
Spinnings 159
Spring materials 24-25, 158
Stampings, punchings 206, 211
Steel
Heat & corrosion resistant..22-23, 29, 43, 76, 86-87, 137, 181
Low alloy 54-55, 62-63, 69, 86-87, 183
Specialty 50-51, 61
Surface patterned 30-31
Tool and die....outside back cover
Strip 22-23, 50-51, 158, 176
Superalloys 157

Testing equipment 184, 192
Tin and its alloys..... 200
Titanium 34, 86-87, 145
Tooling, plastics 8
Tubing & pipe, metallic.....29, 53, 57, 173, 210
Tubing & pipe, nonmetallic..... 9, 152, 162, 166

Weldments 181
Wire 50-51, 70-71, 197
Wire, reactive 207

Zinc and its alloys.....20-21, 45-48

Note: This index includes all advertisers whose copy was received by closing date, the 5th of the month preceding month of issue. Every effort has been made to insure accuracy, but the publisher does not assume responsibility for errors or omissions.

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TECHNICAL LITERATURE

Suppliers' Literature

Books, p 208

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Nonferrous Metals • Parts • Forms

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design information for a line of nonferrous brazing alloys for joining copper, brass and bronze. 181

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Impact Styrene Sheet. Chicago Molded Products Corp. High-gloss surface finish for impact styrene sheet. 198

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Epoxy Resins. Ciba Products Corp., 76 pp, illus., No. 18. Uses, typical properties, types, compatability with other materials, solubilities, viscosities and typical formulations for a series of epoxy resins. 200

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Butyl Rubber. Enjay Co., 12 pp, illus., No. 2d/En. Weather, sunlight, chemical, solvent and heat resistance, electrical properties and uses of butyl rubber. 211

Plastics Laminates. Farley & Loetcher Mfg. Co., Plastics Div., 4 pp. Uses and properties of paper and fabric-base high pressure plastics laminates. 212

Injection Molding Compounds. Fiberfil, Inc., 4 pp. Physical, electrical and chemical properties of Fiberfil Styrene G and Nylon G glass-reinforced injection molding compounds. 213

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Plastics Laminates. Formica Corp., 4 pp, illus. Sizes, uses and grades of paper, canvas, linen, asbestos and glass-base laminated plastics. 217

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Copper-Clad Laminates. National Vulcanized Fibre Co., 6 pp, illus. Properties, uses, grades, and assembly of copper-clad paper-base phenolic laminates. Information also on nylon and glass cloth grades. 233

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Polyethylene Film. Phillips Chemical Co., Plastics Sales Div., 4 pp, illus., No. 6. Strength, rigidity, permeability, chemical resistance, heat sealing characteristics and fabrication of polyethylene films. 235

Extruded Plastics Parts. Pipco International Corp., 76 pp, illus. Dimensions, colors, weights and prices for over 1000 molded and extruded parts made of polyethylene, butyrate, vinyl, nylon and other thermoplastics. 218

Shell Molding. Plastics Engineering Co., 18 pp, illus. Analyzes shell molding process with description of resins developed for manufacturing shell molds. 236

Plastics Coatings. Prufcoat Laboratories, Inc., 4 pp, No. 301. Chemical resistance, properties and uses of vinyl, acrylic, styrene-butadiene, epoxy, phenolic and silicone paints for wood, metals and masonry. 237

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Finishes • Cleaning & Finishing

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Self-Locking Nuts. Mac Lean-Fogg Nut Co., 8 pp, illus., No. 7-Ma. Properties, uses and dimensions of self-locking nuts. **313**

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Fastener Handbook. Ramset Fastening System, 12117 Berea Rd., Cleveland 11, Ohio, 48 pp, illus., No. 5161. Price $2. Installation data, characteristics and uses of powder driven fasteners for wood, steel and concrete.

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Methods & Equipment • Testing

Hardness Tester. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 2 pp, illus., No. TT-58. Dimensions, features, operational data and prices of a Rockwell hardness tester. **333**

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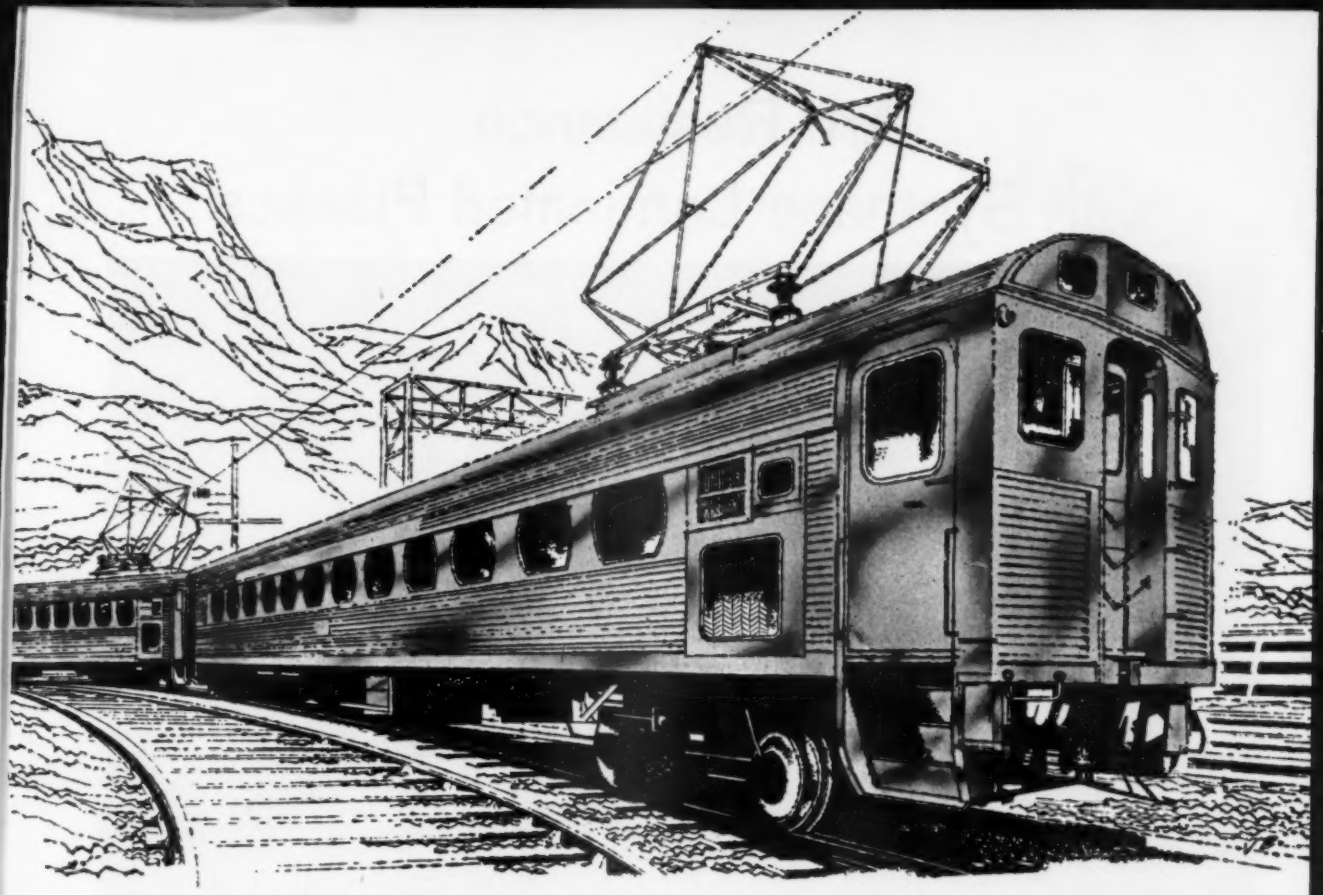

Light as a 128-Passenger Feather

Because it makes practical use of the remarkable strength-weight ratio of the austenitic stainless steels, this all-stainless steel railroad passenger car weighs **25 tons less than other so-called modern equipment.**

It is an important contribution to railroad operating economy and efficiency because its stainless steel structure guarantees millions of miles of service between overhauls —its gleaming exterior requires no paint.

Designed and built by The Budd Company, it is considered one of the greatest engineering achievements of the century—made possible **only** by that brawny beauty stainless steel.

In your product engineering when weight is a problem and strength a necessity the answer can be found in stainless steel's unique combination of strength, durability and beauty.

J&L leads the industry in melt shop standards for stainless steel—the point where quality starts, **and engineering achievement begins.**

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STAINLESS

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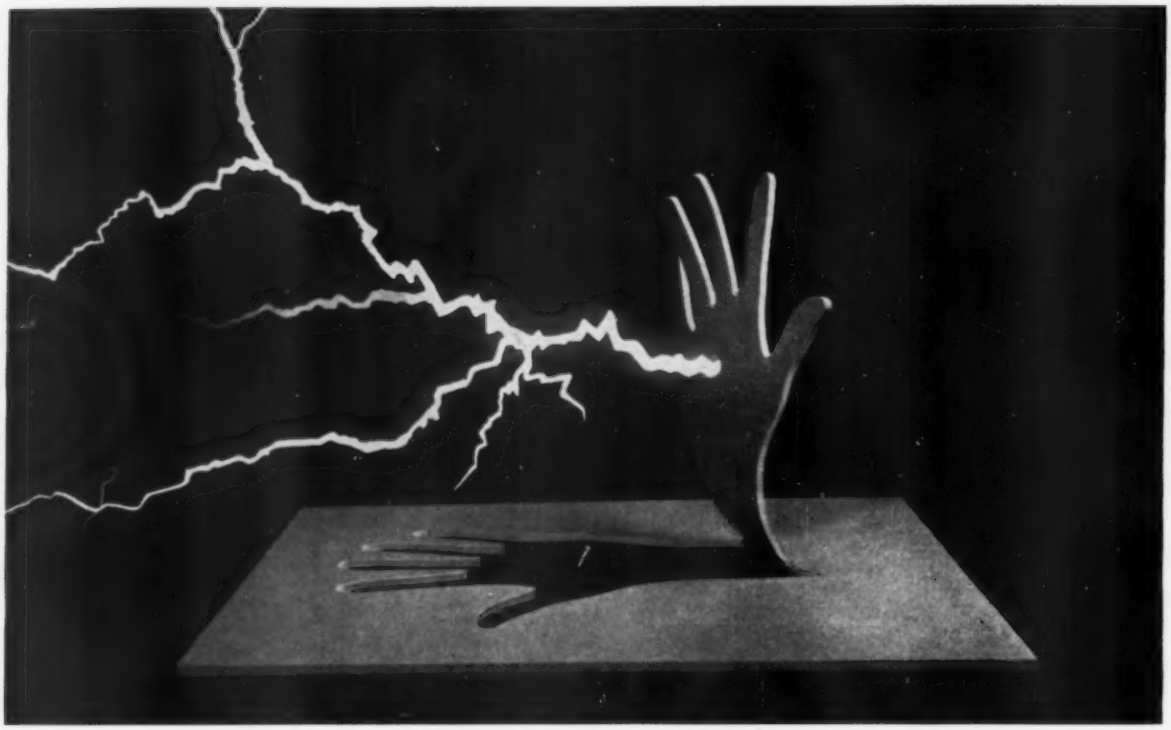
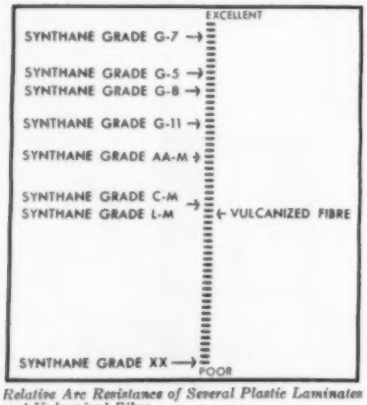
Arc Resistance with Synthane Laminated Plastics



Resistance to arcing is important in such applications as terminal boards, switch and fuse blocks, and circuit breakers. Usually, however, arc resistance alone is not sufficient to satisfy job requirements. Ceramics, for example, are excellent for arc resistance but they break easily and are difficult to machine. Mica has excellent arc resistance yet lacks strength.

Laminates have arc resistance plus

Laminated plastics have many desirable properties in combination. All grades of plastic laminates have good electrical properties. All have good dielectric strength, dissipation factor and insulation resistance. Some laminates also have excellent arc resistance and some—the phenolic laminates, for instance—are relatively poor in this respect.



Relative Arc Resistance of Several Plastic Laminates and Vulcanized Fibre.

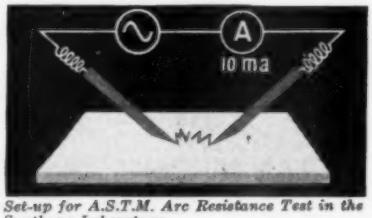
It is this failing of the phenolic grades which may have deterred you from thinking of laminates when arc resistance was required. But, outstanding progress has been made to supply laminates with excellent arc resistance. For example, Grades CM, LM, G-5 and G-7 have outstanding arc resistance properties.

There are several tests for arc resistance. One commonly used is ASTM Method D495-56T, which approximates service conditions in alternating current circuits operating at a high voltage, with currents limited to units and tens of milliamperes. Two pointed electrodes, ¼" apart (see drawing), rest upon the material to be tested. The arc is applied intermittently, and at first mildly. Later the time between flashes is decreased and the amperage is increased until the arc finally burns a conducting path between the electrodes. The total time in seconds until failure occurs is the arc resistance of the material.

Arc resistance is related to time

Since the severity of the arc is progressively increased, the comparative arc resistance of two materials is not in direct proportion to the time. The accompanying chart gives you a fairly accurate relationship of the arc resistance of Synthane laminates—using the ASTM method. The first four are glass base grades. G-7, containing a silicone resin, tops the list in arc resistance as well as in dielectric strength, dissipation factor, insulation resistance and moisture resistance.

For specific information relating to Arc Resistance for your application or for the combined properties of Synthane laminates, write **Synthane Corporation, 3 River Road, Oaks, Pa.**



Set-up for A.S.T.M. Arc Resistance Test in the Synthane Laboratory.

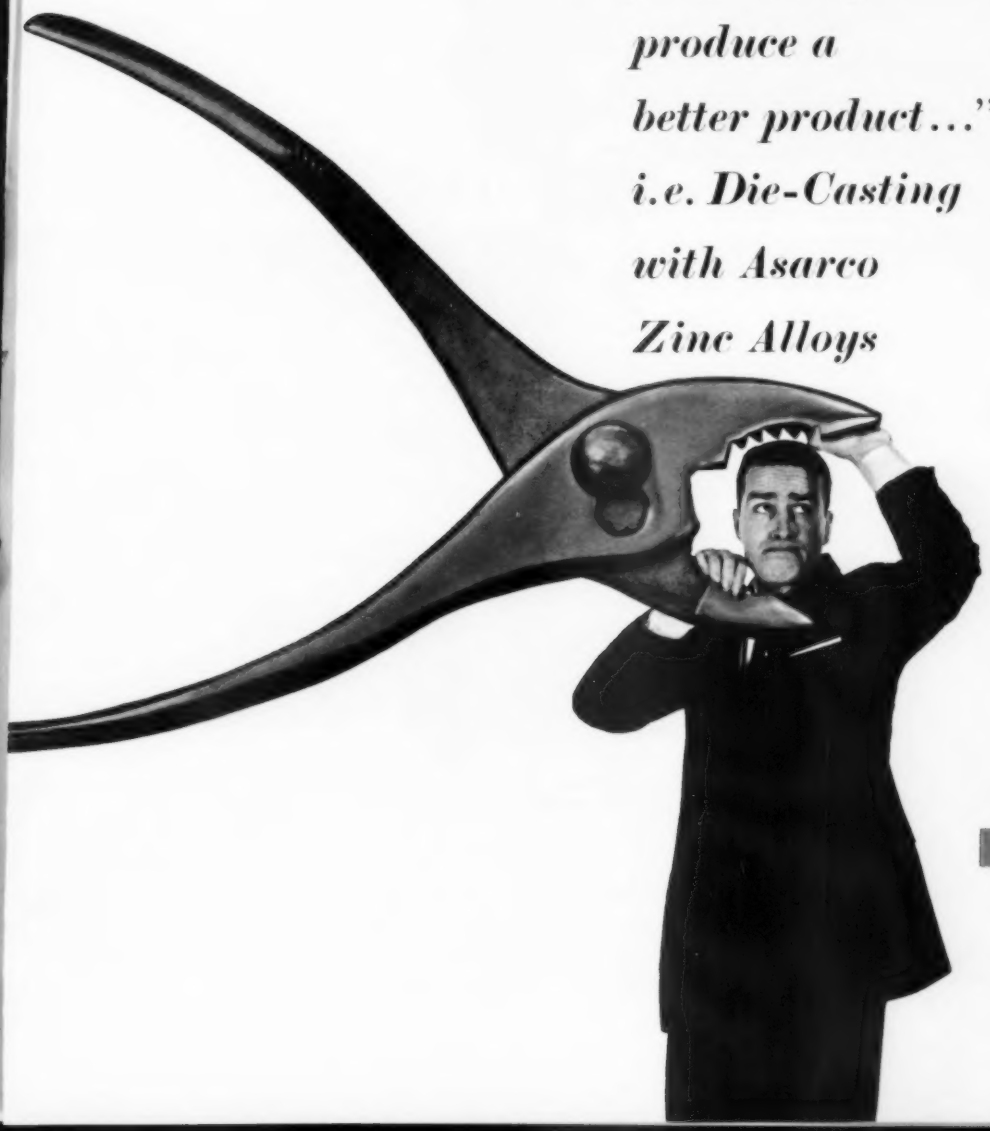
SYNTHANE
CORPORATION **OAKS, PENNA.**
Laminated Plastics for Industry
Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

For more information, turn to Reader Service card, circle No. 437

For more information, circle No. 482

ASARCO

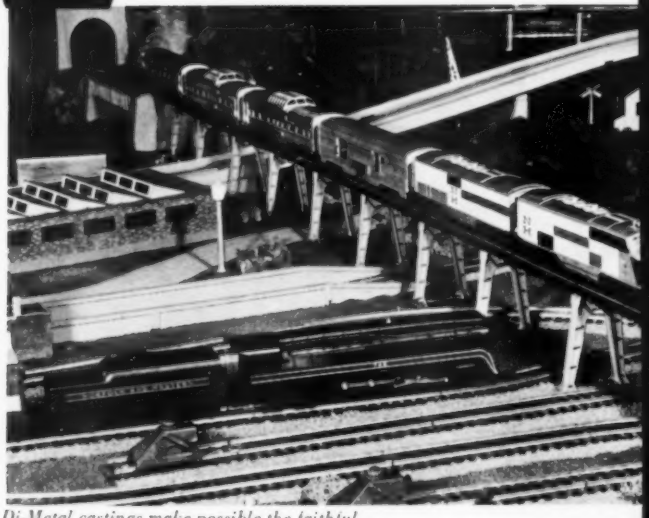
"the fast way out of today's profit squeeze is through the use of more efficient materials which cost less to machine and fabricate, yet produce a better product..."
i.e. Die-Casting with Asarco Zinc Alloys



SEE NEXT PAGE

Die-Casting with Asarco's Federate

Low machining costs, superior castability, and an excellent plating surface are the big reasons why Di-Metal castings are favored for fuel pumps, carburetors, grilles, lamp housings, instrument panels, horn rings, and many other functional and decorative automotive components.



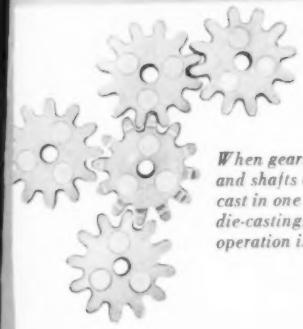
Di-Metal castings make possible the faithful reproduction of detail that's so important in producing trains and other toy miniatures which look "just like the real thing."

The low cost, fine detail, complex shapes, and brilliant finish possible with zinc die-casting has become increasingly appealing to manufacturers of costume jewelry.

Di-Metal Zinc Alloys can cut your costs...and produce a better product in the bargain!

Every designer will sit up and take notice when he sees how easy it is to produce miniature objects with movable parts, even linkage, in one Di-Metal zinc casting. This is actual size of die-cast scissors.

Zinc die-casting provides the hardware field with the smooth cast surfaces so necessary in producing an attractive, lasting finish.



When gears, cams, hubs, and shafts can be integrally cast in one piece by zinc die-casting, a costly assembly operation is eliminated.

There's a big swing in metal parts production today to die casting with zinc—and it certainly makes good sense.

For one thing—Federated Di-Metal (alloyed from Asarco's Special High Grade Zinc 99.99 plus % pure) is lower in material cost.

But the big savings come in production. The low melting point of Federated Di-Metal cuts casting time to the bone. Die casting at lower temperatures calls for less expensive dies—and they last far longer.

Castings can be held to very close dimensional tolerances so that there's a minimum of machining and finishing. And even when this is necessary, highly ductile zinc is easy to work.

Die casting with Federated Di-Metal can produce the most complex shapes, the thinnest section walls, the smoothest casting surfaces. The castings have impact strength and other mechanical properties superior to other casting metals (with the possible exception of copper which, of course, costs more). And zinc die-castings can be readily electroplated or coated.

When you're both cost and quality conscious, you can't afford to by-pass die casting with Federated Di-Metal. It is proving the fastest way out of the present "profit squeeze" for a growing list of manufacturers in many fields.

When You Die-Cast Your Product with Asarco's Federated Zinc Di-Metal, You Profit from:

1. Integrated Production. Federated Di-Metal is alloyed using electrolytically refined Special High Grade Zinc from ores mined by Asarco. Alloys are produced "under one roof" at Corpus Christi, Texas, one of the world's largest electro zinc producing plants – assurance of highest purity and uniformity at lowest cost.
2. Nation-wide Service and Distribution. Always a Federated field engineer near you, on call from 23 sales offices throughout the country. Federated Di-Metal is stocked for immediate shipment from a nation-wide system of distribution centers.
3. Asarco booklets and bulletins of great working assistance to the die casting industry, detailing efficient working practices, selection of alloys, vital technical data. Write for your free copy of "For Better Die Castings," to your nearest Federated Sales Office or to ASARCO Federated Metals Division, 120 Broadway, New York 5, New York.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

Other ways it pays to THINK ZINC when you're cost-and-quality conscious:

GALVANIZED STEEL. The strength of steel, the corrosion resistance of zinc—at low cost. New processing methods assure uniformly thick zinc coating. Galvanized steel can be drawn or formed. Roofing and siding sheets for farm and industrial buildings are low in initial cost, installation cost, and maintenance cost. Corrugated culvert pipe is easy to transport and install, flexible, strong, durable. Galvanized sheets are superior materials in heating and air-conditioning installations—cost less, fabricate more easily, are more rigid for longer unsupported spans, operate quieter since they expand and contract less than comparable materials.

Zinc products available from Asarco:

ZINC SLAB, Prime Western, Brass Special, Intermediate, High Grade, Special High Grade;
ZINC ANODES for cathodic protection of ship hulls and other submerged steel structures;
ZINC DUST, 97% metallic zinc, 97% through 325 mesh screen;
ZINC FOIL for barrier wraps, insulation;
ZINC ALLOYS for die-casting.

Federated Sales Offices

ALTON, ILLINOIS
Alton Phone: Alton 5-2511
St. Louis phone: Jackson 4-4040

BALTIMORE 24, MARYLAND
Highland & Eastbourne Aves.
Phone: Orleans 5-2400

BIRMINGHAM, ALA.
416 Dalton Drive
Phone: Fairfax 2-1802

BOSTON 16, MASS.
Statler Office Bldg.
20 Providence Street
Phone: Liberty 2-0797

CHICAGO, ILL. (WHITING)
123d St. & Indianapolis Blvd.
Chicago phone: Essex 5-5000
Whiting phone: Whiting 826

CINCINNATI, OHIO
1603 Carew Tower
Phone: Cherry 1-1678

CLEVELAND, OHIO
Hanna Building
1422 Euclid Avenue
Phone: Prospect 1-2175

DALLAS, TEXAS
Phone: Adams 5-5034

DETROIT 2, MICHIGAN
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7430 2nd Avenue
Phone: Trinity 1-5040

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1213 Mills Building
(Asarco Mercantile Co.)
Phone: 3-1852

HOUSTON 29, TEXAS
9000 Market Street Road
P.O. Box 24038
Phone: Orchard 4-7611

LOS ANGELES 23, CALIF.
4010 East 26th Street
Phone: Angelus 8-4291

MILWAUKEE 10, WIS.
4608 West Burleigh St.
Phone: Hilltop 5-7430

MINNEAPOLIS, MINN.
Phone: Tuxedo 1-4109

NEWARK, NEW JERSEY
150 St. Charles Street
Newark phone: Mitchell 3-0500
New York phone: Digby 4-9460

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Phone: Locust 7-5129

PITTSBURGH 24, PENNA.
615 Gross Street
Phone: Museum 2-2410

PORTLAND 9, OREGON
1900 N.W. 18th Avenue
Phone: Capitol 7-1404

ROCHESTER 4, NEW YORK
Triangle Building
335 East Main Street
Phone: Locust 2-5250

ST. LOUIS, MISSOURI
Mail Address: Alton, Ill.
Phone: Jackson 4-4040

SALT LAKE CITY 1, UTAH
700 Crandall Bldg.
Phone: Empire 4-3601

SAN FRANCISCO 24, CALIF.
1901 Army Street
Phone: Atwater 2-3340

SEATTLE 4, WASHINGTON
101 Dakota Street
Phone: Main 3-7160

WHITING, IND. (CHICAGO)
123d St. & Indianapolis Blvd.
Whiting phone: Whiting 826
Chicago phone: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmont Rd. Scarborough, Phone: Plymouth 7-3246
Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591

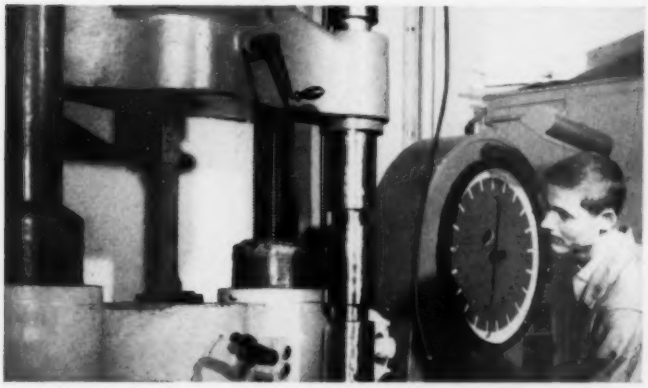
ASARCO

ARMCO STEELS / for better products • lower costs

Stretched to the Breaking Point!

Armco ZINCGRIP Doesn't Flake or Peel

Tension tests prove the special Armco hot-dip zinc coating won't flake or peel even when the base metal is pulled apart. The coating on ZINCGRIP® adheres tightly right up to the broken edge.



Tensile test specimens of Armco ZINCGRIP Steel, with grid lines to show extent of stretching, are pulled to fracture. Elongation of about 70%, in the area of the fracture, caused no flaking or peeling of the special hot-dip zinc coating.

These tensile test specimens dramatically demonstrate how Armco ZINCGRIP Steel can be deformed without damaging its rust-resisting zinc coating. Nowhere on the specimens, cross-hatched to show amount of stretching, is there any evidence of flaking or peeling of the zinc coating. Even at the edge of the fracture, the base metal is still protected by the ductile, adherent coating.

Draws, Forms, Bends

Results of tensile tests aren't the only evidence of the unusual ductility of the protective coating on Armco ZINCGRIP. For almost a quarter-century this has been demonstrated in plants throughout the country where it has been drawn, formed, pierced, bent, extruded and stamped without flaking or peeling the zinc coating.

Get complete information on the properties, and fabrication of Armco ZINCGRIP Steel. Write Armco Steel Corporation 2779 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

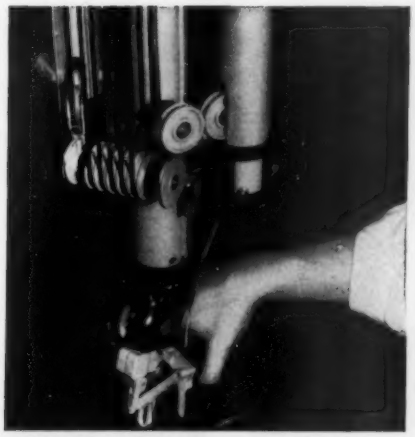
For more information, turn to Reader Service card, circle No. 391

How NS solved another special steel problem

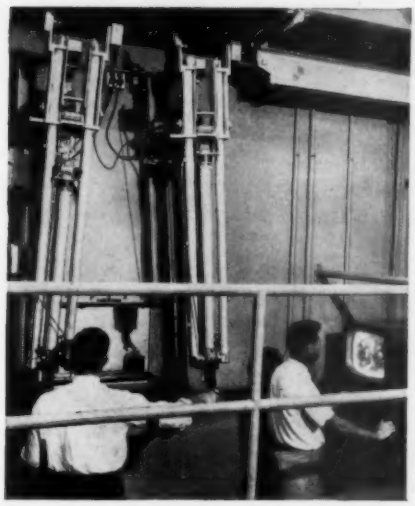
Photos courtesy of Nuclear Systems Division, The Budd Company

RADIOACTIVE MATERIAL is handled remotely by operator from behind three-foot thick lead-glass wall. Nilcor strips, which make quick, accurate system response possible, can be seen running vertically from pulleys just above operator's hands.

SPECIAL NS-ATHENIA STEEL PUTS LIFE IN ATOMIC-AGE ROBOT



HAND MOVEMENTS at operator end of master-slave system are translated without distortion, or time lag through seven Nilcor strips (shown in photo) that travel through 15-foot belt and pulley system.



OPERATOR STATION, shielded by protective wall, has television monitor screen where action inside radioactive room is reproduced as operator manipulates controls of master-slave system.

To manipulate radioactive materials with lifelike dexterity, from the other side of a three-foot thick protective wall, requires robot controls with a high degree of precision and quick response.

Ordinary cable or belt arrangements gave too much stretch between the operator's "master" hand movements and the identical "slave" movement at the other end of the system. Movements had to be translated almost instantaneously and duplicated exactly at the slave end of the system. To help solve this problem, robot system manufacturers came to the Athenia Steel Division of National-Standard to find a strip material that would serve in the belt-and-pulley arrangement of the mechanism with minimum stretch and friction and without backlashing or overshooting.

NATIONAL-STANDARD ENGINEERS at Athenia in Clifton, N. J., recommended Nilcor* strip (basically a cobalt-chromium-nickel alloy) because of its high fatigue resistance, high tensile strength and exceptionally high corrosion resistance—plus less than ⅛-inch lateral sweep per 8-foot length when laying flat without tension. Experiments with .005 Nilcor strip in the robot systems showed an 80% reduction in stretch and 90% reduction in friction over standard wire materials.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring specialty steel and wire to meet unique applications, is available to *you* from National-Standard. For the many thousands of applications where only specialty steel or wire will solve the problem, let National-Standard engineers go to work for you. Write for additional information to National-Standard Company, Niles, Michigan.

*Trade Mark

Manufacturer of Specialty Wire and Metal Products

NATIONAL NS NATIONAL-STANDARD Company NILES, MICHIGAN **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; tire wire, stainless, music spring and plated wires • **WORCESTER WIRE WORKS** Worcester, Mass.; high and low carbon specialty wires • **WAGNER LITHO MACHINERY,** Secaucus, N. J.; metal decorating equipment • **ATHENIA STEEL,** Clifton, N. J.; flat, high-carbon spring steels • **REYNOLDS WIRE,** Dixon, Ill.; industrial wire cloth • **CROSS PERFORATED METALS,** Carbondale, Pa.; decorative, commercial, and industrial perforated metals.

For more information, turn to Reader Service card, circle No. 453

THE ONES THAT WILL LAST (and last, and last!)? THOSE MADE FROM CONTINUOUS PROCESS ZINC-COATED STEEL SHEETS

And just why will they last and last?

The people of the Galvanized Container Industry, always alert to make improvements to keep their products the best, can give you a multitude of reasons why. Chief among them: the continuous process insures a uniformly applied, corrosion-resistant zinc-coating. In fact, the zinc and steel are integrated to form a tight bond for every square inch, a durable coating which stands up to any rigorous stress of the fabrication process.

Continuous process zinc-coating will not chip or flake, no matter how much it is twisted, crimped or lock seamed. It can be worked to the very limits of the steel itself! Your budget benefits because there is no need for additional coating of any kind.

In continuous process zinc-coated steel, there is a stand-out—Weirkote. On your production lines and in your products, Weirkote will work for you all of the time. For detailed information on the many advantages of Weirkote zinc-coated steel, write today for a brochure. Weirton Steel Company, Dept. E-19, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

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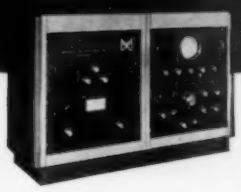
PLANNED FOR PRECISION

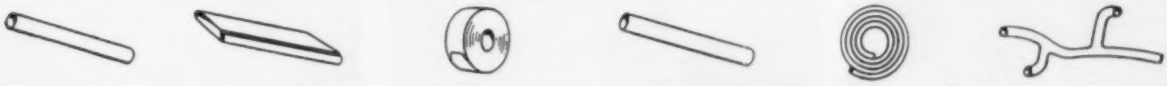
more to H&H quality



The bright, clean, uniform color of H & H tubing, the burr-free ends tells of quality you can *see*. But today scientific instruments like the Magnaflux unit pictured at the left, watch for tubing imperfections the human eye *can't* see. So if you want tubing that's free of all inclusions, laminations, laps and slivers, tubing that's free of any wavy conditions inside or out, it will pay you to always remember you can *depend* on H & H.

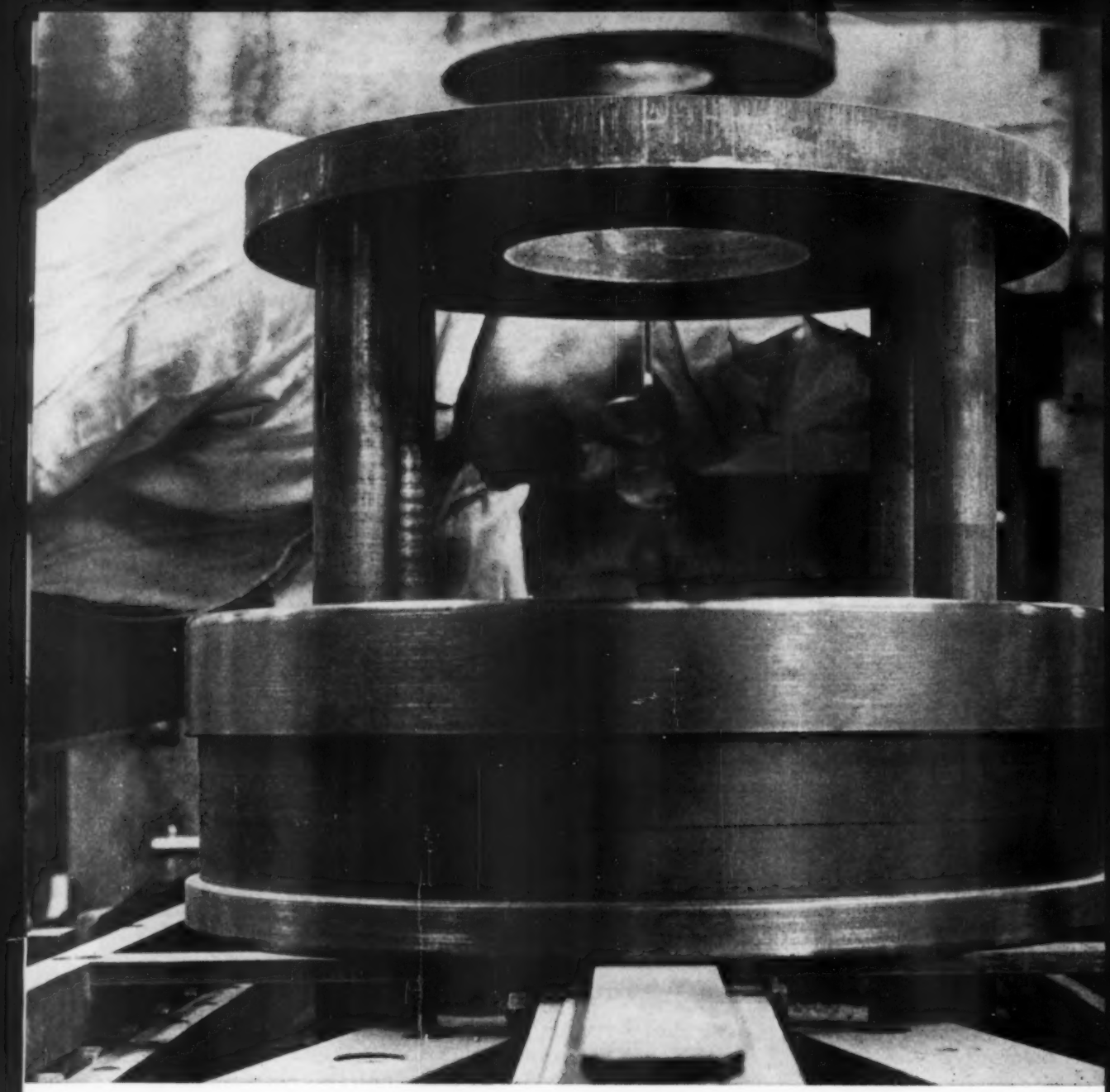
H&H TUBE AND MANUFACTURING CO.

271 *N. Forman Avenue, Detroit 17, Michigan • Offices from Coast to Coast*



METALFLO LOCKSEAM COIL STRIP SEAMLESS TUBING TUBULAR PARTS

For more information, turn to Reader Service card, circle No. 488



Here's a tough old squeezer that won't wear out

The donut-shaped steel disc in the main illustration is the mold plate used in a large hydraulic press. Under 2,000 tons of pressure, it squeezes an abrasive mixture in a mold to make grinding wheels. It's a tough job, and Waltham Grinding Wheel Company had to replace these discs every few months because they wore down and became unbalanced. Replacements were expensive and they wasted production time.

Finally, Waltham tried a plate made of USS "T-1" Steel. It has been used for more than a year now, and Waltham engineers say it will last indefinitely.

"T-1" constructional alloy steel has a minimum yield strength of 100,000 psi. It is exceptionally tough and resistant to abrasion—can be furnished heat treated to a minimum hardness of 321 Brinell. Compared to carbon steel, it has four times more resistance to atmospheric corrosion. In spite of its strength and toughness, "T-1" Steel can be formed, machined and welded. And because of its strength, it can be used in lighter gages, reducing weight as much as ⅔, depending on the application.

If you would like to have complete information about "T-1" Steel, write for our book "USS 'T-1' Steel," United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS and "T-1" are registered trademarks

USS

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

#3
INGENUITY: Key to Successful Honeycomb Sandwich Design

In most actual honeycomb sandwich applications the success of the design is a direct measure of the ingenuity of the designer. The reason for the heavy dependence on the designer's resourcefulness is that the details of such light weight composite materials require many unusual innovations in order to carry in loads which are higher than can be normally sustained by the overall structure.

Typical of such problems is the design of an attachment point, or tie-down fitting, in the middle of a sandwich floor. Figure 1 illustrates a satisfactory design wherein the material tie-down fitting is accomplished through a wooden block which distributes concentrated loads created by the fasteners. Figure 2 illustrates another load distribution technique utilizing a molded or poured plastic block.

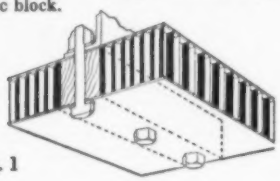


Fig. 1

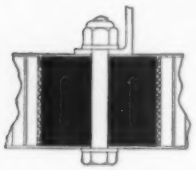


Fig. 2

A large diameter washer under the bolt head will further aid in load distribution.

Edge Details

The edges of a sandwich structure are not normally required to be sealed off for environmental purposes since most core materials are resistant to normal atmospheric exposure. It usually is imperative, however, to close the edges off to prevent incidental damage to the core and to provide strengthening of the sandwich to carry edge attachment loads. Sketches of typical edge details are shown in Figure #3.

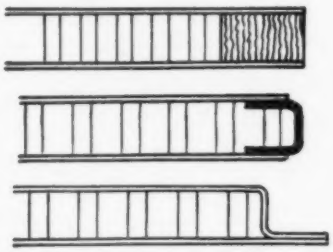


Fig. 3

A simple inspection of the various means shown should provide an idea for a method suitable for a design capable of meeting any specific edge loading.

Adding Strength in Critical Areas

In many designs it is desirable to have the overall light weight of a sandwich structure, but it is still necessary to meet extremely high load requirements in some localized areas. These conditions can be met by using a high density honeycomb in the local area, by adding doublers under the skin, or by the use of various composites of inserts as shown in Figure #4.

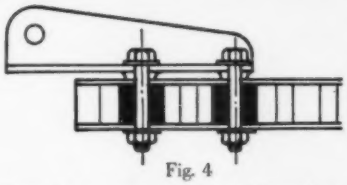


Fig. 4

These design types are typical of those being used today in designs which permit an improvement in strength-weight ratio of four to ten times.

Such results signal even greater achievements ahead as designers become more intimately familiar with the design opportunities offered by composite honeycomb structures.

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

Honeycomb has intrinsic qualities of high strength, light weight, high ratio of surface area to volume and other specific properties which depend upon the type of material used. These combinations of properties, which have given honeycomb wide application in air and space craft, offer to designers in industry generally unique opportunities in product design. In the interest of advancing this knowledge of honeycomb, Hexcel, through its research and development staff (the industry's largest), has prepared this informational series. Should you desire additional technical information or copies of others in this series, please complete the information request form on this page. Your request will receive immediate attention.

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept "M-2"
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Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.
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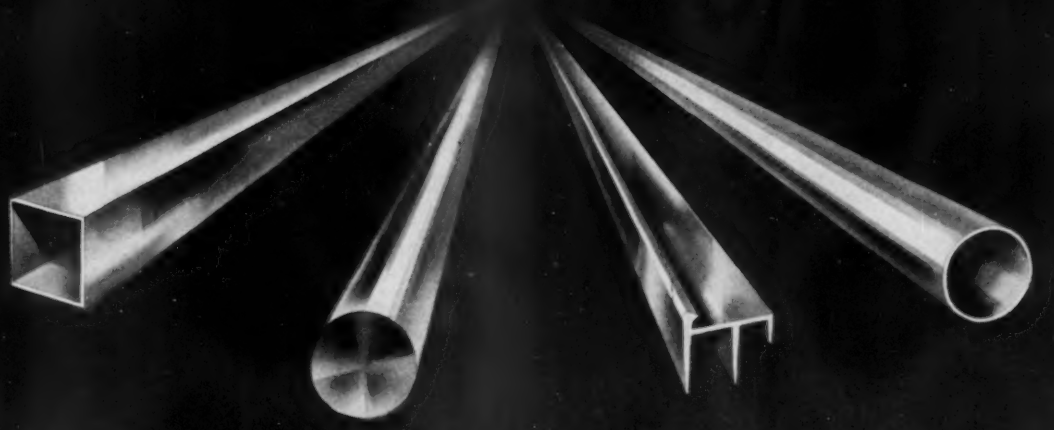

Wolverine Tube is experienced in working with the special metals listed above.

Anticipating their growing importance Wolverine has, for a number of years, engaged in an extensive research and development program designed to fully exploit their characteristics.

The results of this specialized knowledge and experience are now available to American industry. Recently the longest length of columbium tubing yet fabricated in the United States came from Wolverine Tube's Detroit Plant.

Wolverine has also conducted special training in these metals for its staff of nationally-based Technical Sales Representatives.

For complete information ask for the services of a Wolverine Technical Sales Representative. Write, too, for a free copy of the Wolverine Nuclear Catalog.

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CAPTURING CHLORINE ATOMS TO MAKE ACHROMYCIN*...TETRACYCLINE

Where no metal but Palladium

ONLY A PLATINUM METAL DOES IT. This black powder is catalyst . . . Palladium, a platinum metal, dispersed on activated charcoal. It has just been recovered intact, after catalyzing the chemical reaction by which tetracycline is produced from chlortetracycline, at Lederle Laboratories.

Suppose *you* were asked to "operate" on a complex molecule to remove a single chlorine atom without disturbing at all other atoms in this tiny bit of matter.

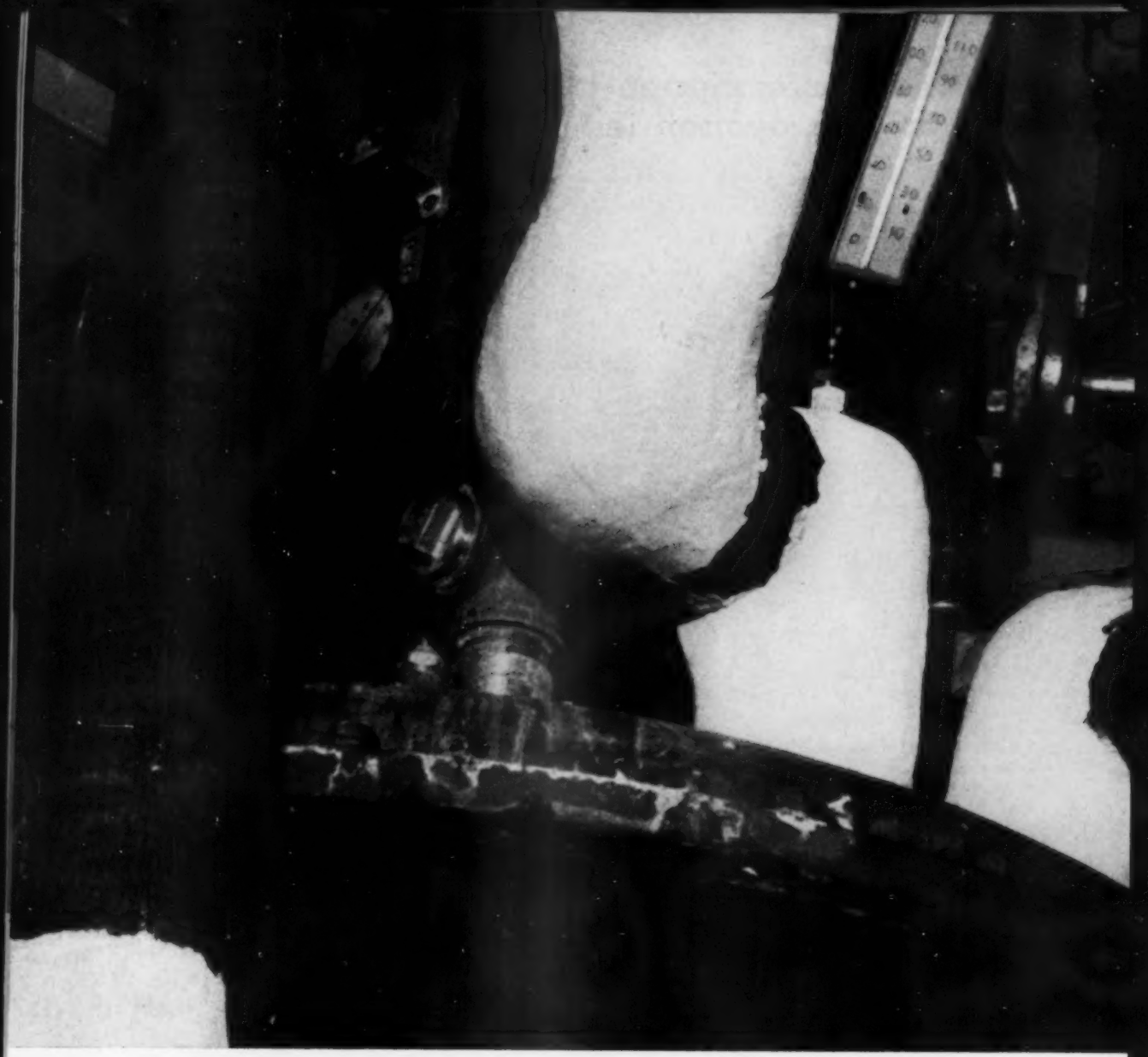
Incredibly, such "operations" are routine . . . performed every day on a mass production basis at Lederle Laboratories. That's how, in the equipment shown above, chlortetracycline is converted to tetracycline . . . an effective antibiotic with minimum side reactions.

The "scalpels" Lederle uses to perform this operation are hydrogen atoms. Palladium catalyst dispersed on particles of activated charcoal, guides the hydrogen atoms. No one knows exactly how palladium does this . . . but the effects are clear. When palladium is present, the hydrogen atom goes into action and removes the chlorine atom from each chlortetracycline molecule.

Palladium is the one most effective way to spark this chemical reaction. Equally important, it is not lost . . . is totally recoverable.

The unique properties of the Platinum Metals may prove useful to you

Today the catalytic properties of the platinum metals are being applied in almost endless ways . . . upping the octane ratings of gasolines, activating flameless hand warmers for sportsmen, detecting fires *before* they spread, sensing the presence of lethal fumes.



will do the job as well...

Also, where a hard surface, immune to tarnish, is required, as in electrical contacts . . . where conditions involve high temperatures and product purity, as in the production of lens glasses . . . or where a combination of severe corrosion or erosion must be met, as in the case of spinnerettes for rayon production . . . the platinum metals often prove to be the most economical materials for critical equipment.

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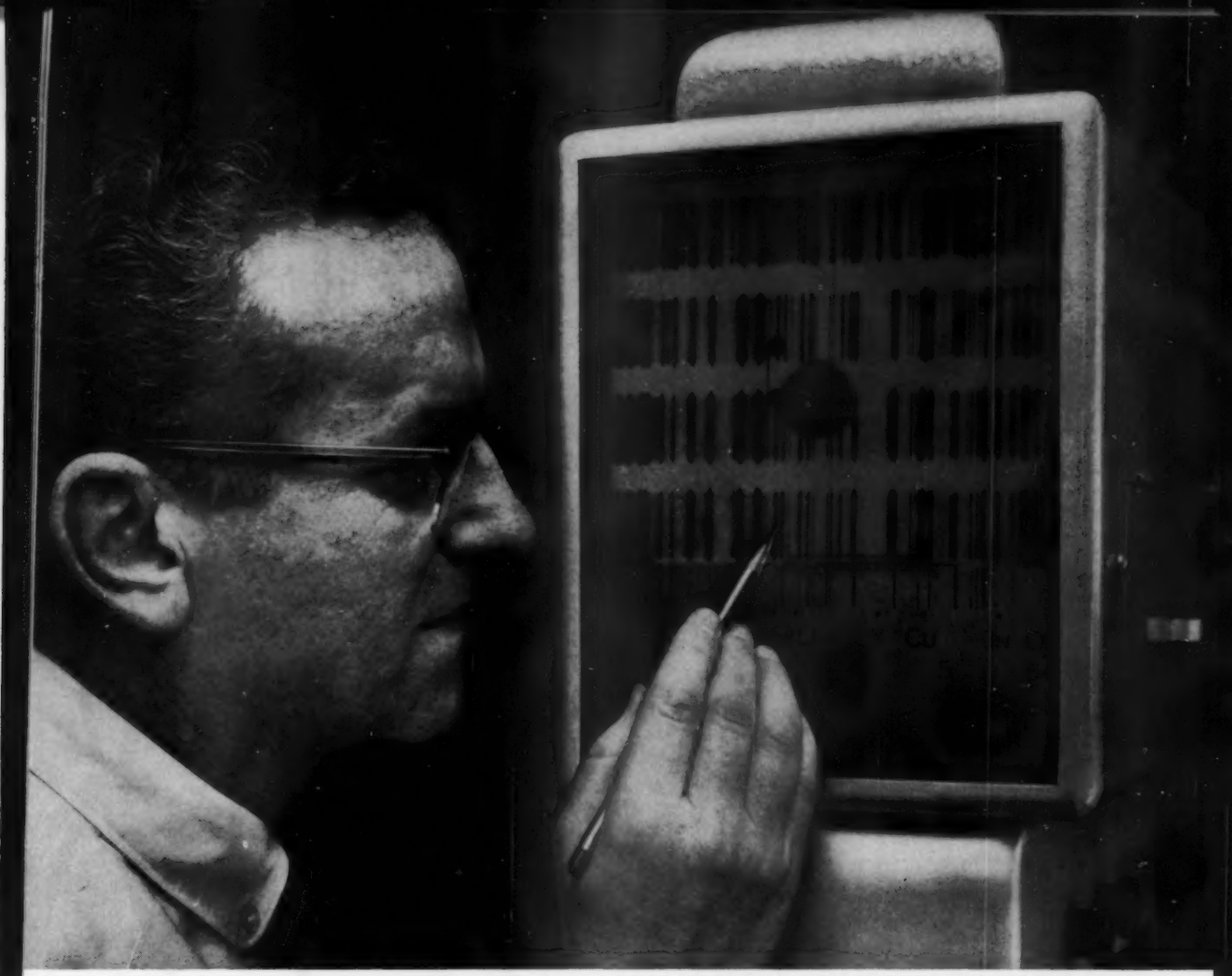

Using this microphotometer, Jessop can detect and measure the per cent of even trace elements in a sample of specialty steel.

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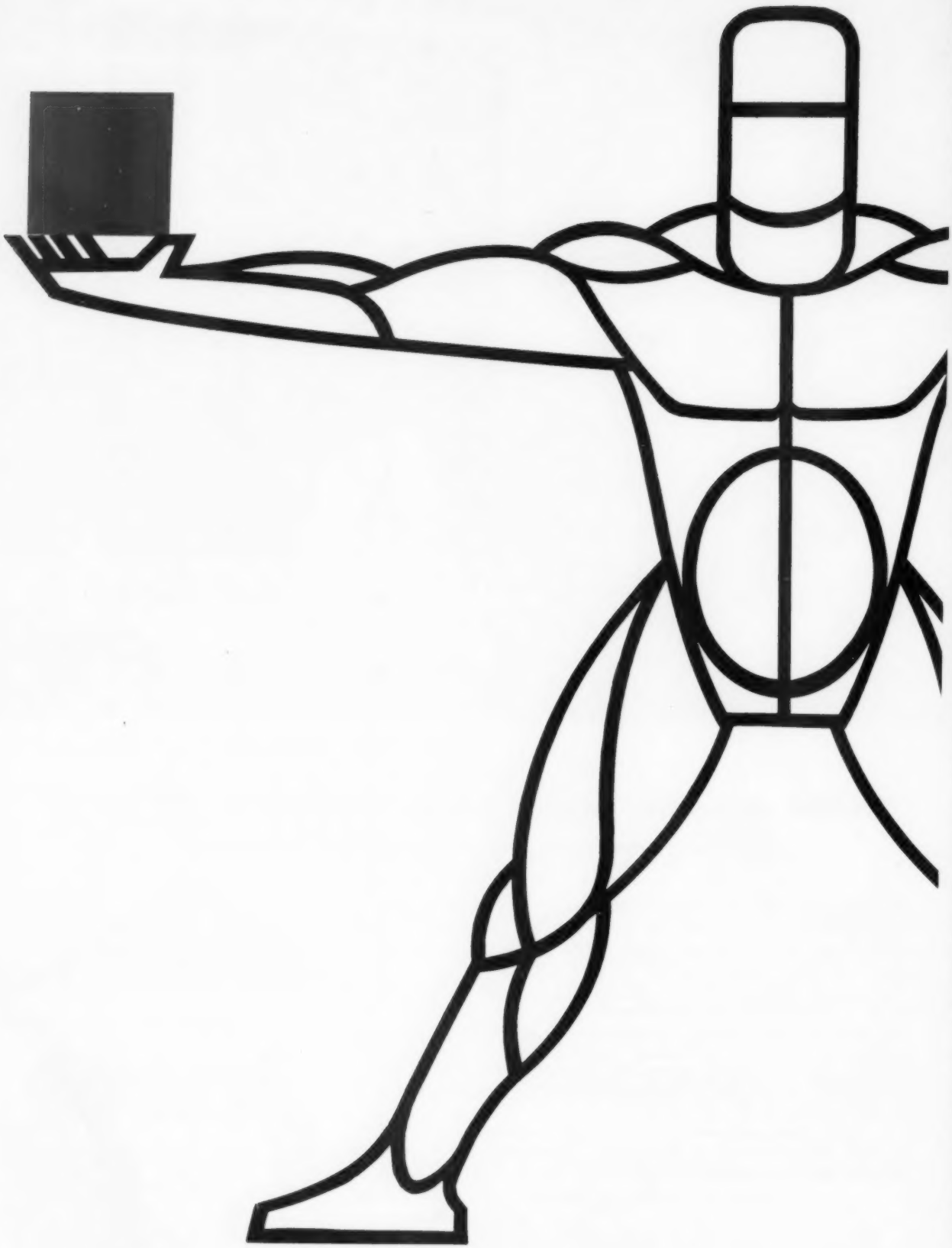

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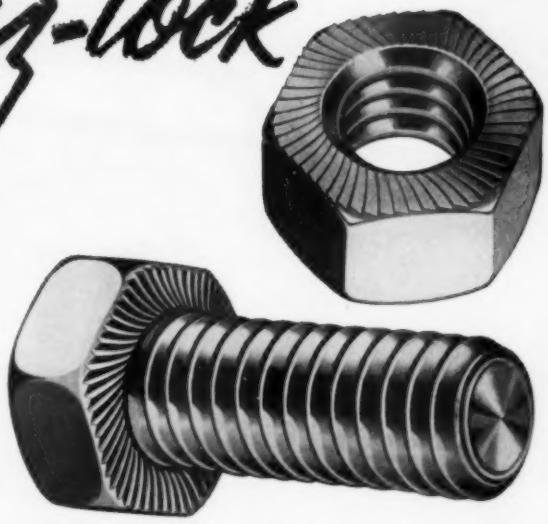
the MF whiz-lock



STARTLING RESULTS

Out of M-F research and development labs has come a lock nut that has amazed even those who first conceived it. A free-spinning surface-bearing lock and tension nut which surpassed expectations even in the earlier models.

The Whiz-Lock principle (an entirely new concept in fastening) has been a well-kept secret for over a year. Now patent applications are in—and this startling device is ready for designers, engineers and production men to uncover new properties and uses for this amazing fastener.

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Whiz-Lock was released *only* when its *design* was capable of *precision* manufacture on *conventional* machinery. Thus *Whiz-Lock* is *NOT* a premium-priced nut!

Try this amazing Whiz-Lock test for yourself!

Apply, a common nut with as much torque as you can. Torque to release *it* doesn't even reach application torque.

Now spin on a Whiz-Lock, tighten—and try to break it loose! (Caution: *do not attempt on glass-top or light-weight desks.*)

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UNIFORM TORQUE-TENSION *HIGHEST* "BREAK-LOOSE" TORQUE

THE ANGLE of the BASE

EFFICIENT on *ANY* SURFACE (even depressed side of punched holes) *INITIAL* CONTACT and LOCK IMMEDIATELY NEXT TO SCREW or BOLT HOLE *ALL* LOCKING STRENGTH WITHIN NUT CIRCUMFERENCE

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• One piece • Free spinning • Very high tension • High strength—heat treated • High re-useability • Consistent—*uniform* torque tension • Highest release torque to application torque • Low cost

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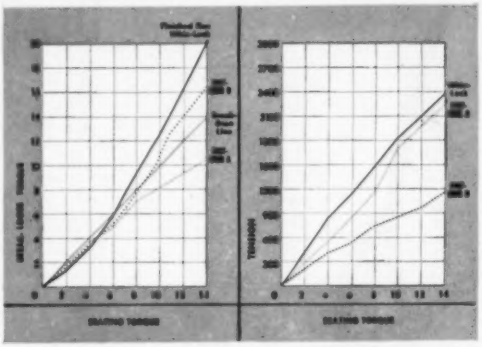
TORQUE-TENSION CHART



NOTE the excellent torque-tension and "apply and release" ratio of the M-F Whiz-Lock in *both* tests.

For oversize holes or wherever flange use is indicated, the same WHIZ-LOCK principle is available in flange nuts and screws.

SEND FOR BROCHURE...information on sizes and dimensions...M-F Whiz-Lock Nuts and Screws and M-F Flange Nuts and Screws

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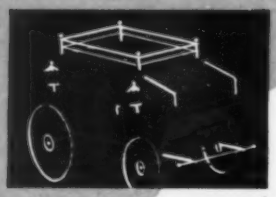

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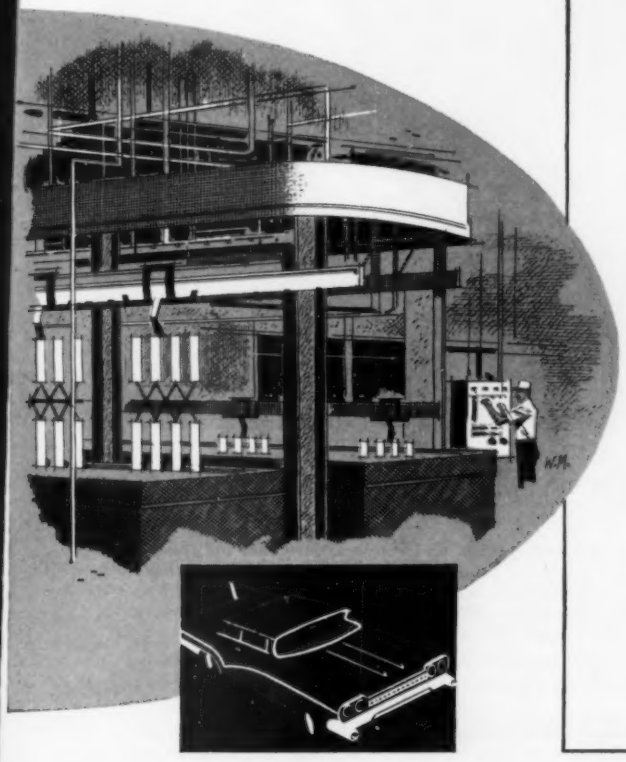
Nickel salts, nickel anodes, and cyanide of potash were Harshaw products produced for the Plating Industry as early as 1899. This modest beginning grew continuously to where our service to Platers includes full programs of research and development, many plating processes, and a complete line of chemicals and anodes. We will be happy to send further information on any of the items listed here—ask us for it.



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Caustic Potash
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Containers, Ball Anode
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Carbon	.40	Chromium	5.00
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plus Alloy Sulphides

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Ultimate Strength, psi	200,000
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More and more machine tool components and maintenance parts are being made of Latrobe's prehardened VISCOUNT 44. Why? Because this steel is easy to machine—has unexcelled strength, good toughness and exceptional wearing qualities. Suitable for parts operating up to temperatures of 1000°F. Prehardened, Viscount 44 eliminates risk of size change and distortion resulting from heat treatment.

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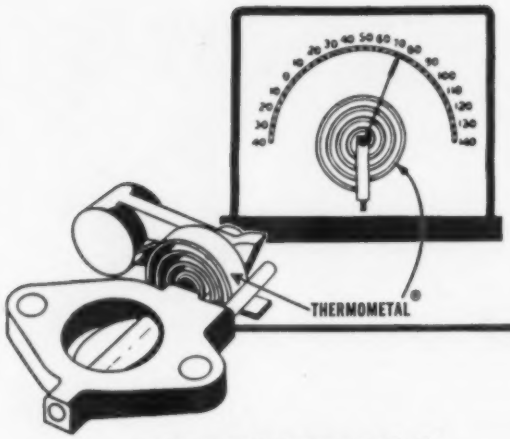

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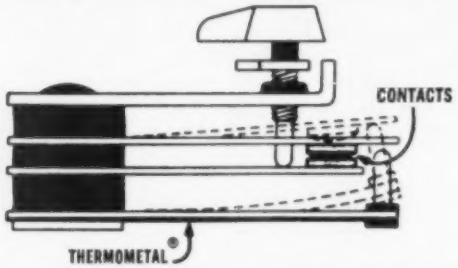

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Amersil manufactures and fabricates high purity fused quartz for ultraviolet transmission applications, laboratory ware and production equipment. These products include standard apparatus, plain tubing in many intricate fabrications, crucibles, trays, cylindrical containers and piping in a full range of sizes up to 25" in diameter. Ingots and plates are available in general commercial quality as well as in special optical grades. Amersil engineers are also prepared to assist in developing fused quartz and silica equipment for special requirements. Send for bulletin.

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a simplified mirror-bright silver plating process

Here is the most efficient, simple procedure to protect electrical electronic and lamp components with a mirror-bright silver finish—through a complete range from flash to heavy deposit. The procedure is easy, economical and non-critical—with little or no polishing required. Silva-Brite is a clear, water-white solution, enabling the operator to observe work as it is being plated. Uniformly good results are attained with current densities ranging from 10 to 40 amperes per square foot. Normal room temperature operation minimizes fumes and tendency toward bath decomposition. Send for descriptive data together with detailed plating procedures.

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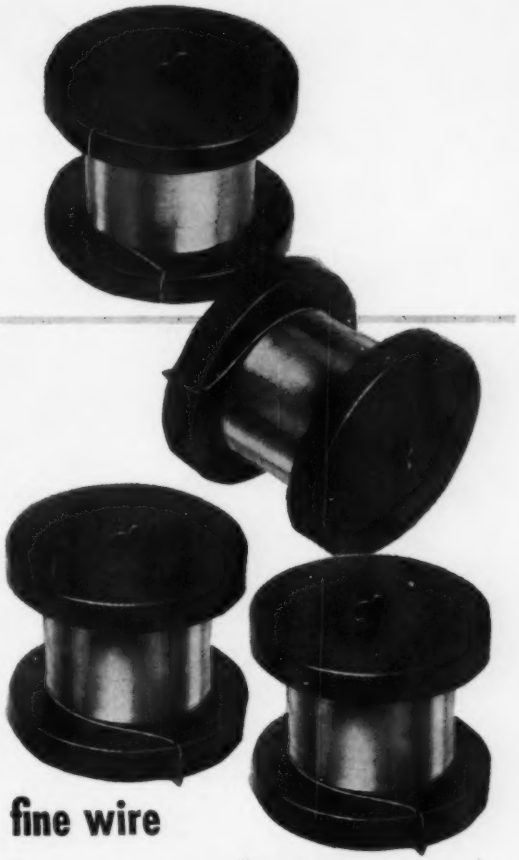

fine wire for every application

Here, you will find a thoroughly dependable source for fine wire of ductile and non-ductile materials for every application. Special processes have been developed for bare drawing wire as fine as .0004". Where smaller fine wire is required, the Wollaston Process for ductile metals and the Taylor and Extrusion methods for non-ductile materials are employed. All standard fine wire requirements are stocked for prompt delivery. Full facilities are available for the production of fine wires made to your own specifications.

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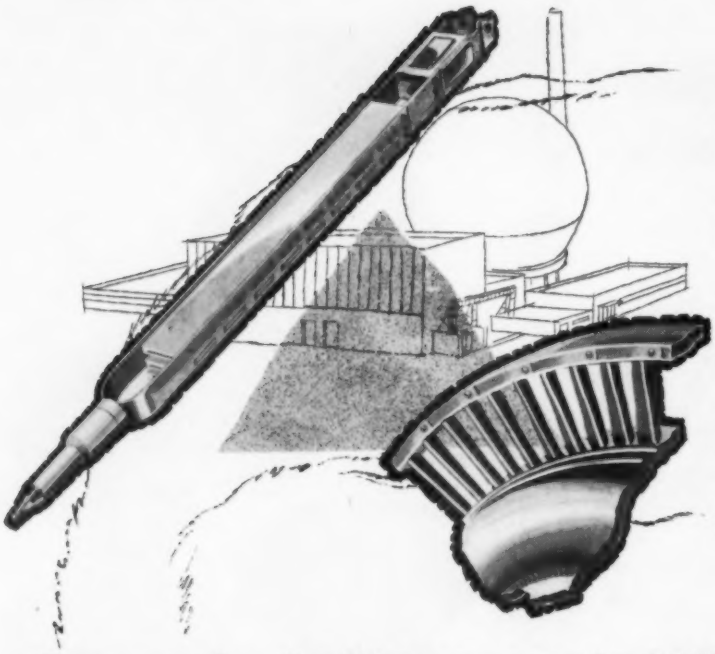

Today's metallurgical engineers and scientists are constantly meeting the challenge of sweeping technological advances. Electronic brains that solve "impossible" problems . . . jets and space craft which open brand-new horizons . . . reactors that produce fantastic amounts of nuclear energy. Advances such as these *demand* better metals . . . metals free of inclusions, with better electrical conductivity, increased hot strength, extended creep resistance and fatigue limits. In turn, better refractories are a "must" in order to precisely control purity and composition during the development of these metals.

Metal processors have long relied on the wide range of Norton Refractory products to precisely meet their re-

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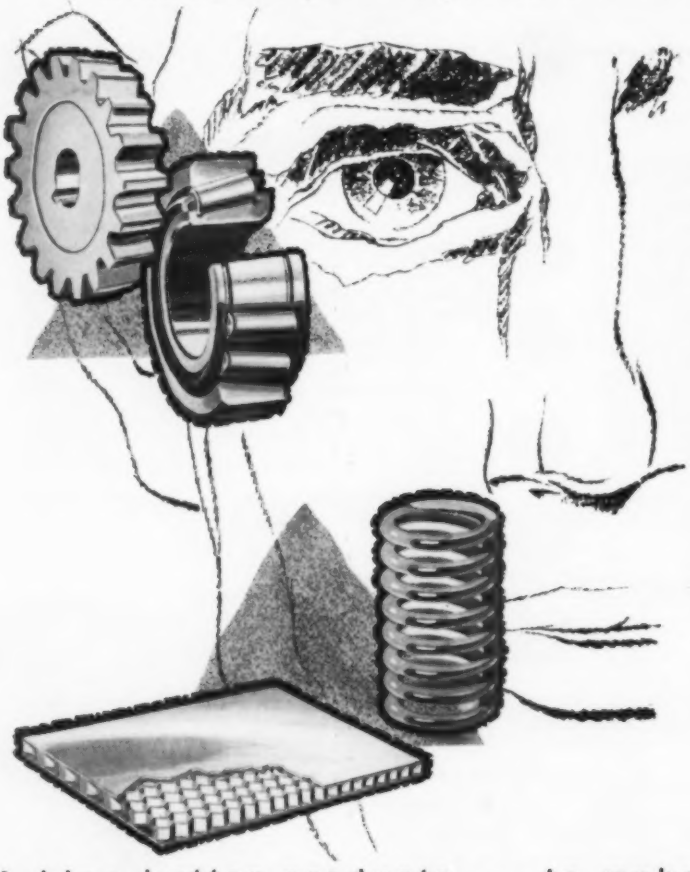
..reflect the positive protection of Norton Refractories



quirements. High purity (99.5%) ALUNDUM* aluminum oxide, outstandingly stable to both oxidizing and reducing atmospheres . . . dense, fused, stabilized Zirconia for operations requiring an inert refractory for extremely high temperatures . . . nonwetting, nitride-bonded CRYSTOLON* silicon carbide...low boron MAGNORITE* magnesium oxide, ideal for vacuum melting. In addition, the Norton Man is constantly helping in process and product development. Backed by Norton Company's extensive engineering facilities, he can offer time and money-saving advice on all refractory problems.

Meet *your* processing requirements more efficiently and economically with Norton Products and Engineering. For complete details write NORTON COMPANY, Refractories Division, 347 New Bond Street, Worcester 6, Mass.

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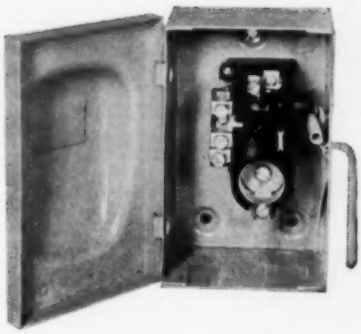
PRODUCT-DESIGN BRIEFS FROM DUREZ

- **New safety switch idea**
- **Phenolics in data processing**
- **What's hot in heat resistance**



A switch for fumblers

Ever try to change a fuse on a 30-amp switch in pitch darkness?

"No—and why should we?" retort the designers of many such useful devices. "Anyone who doesn't have a flashlight handy for these little emergencies is asking for trouble."

"Yes—and it was a horrible experience," breathes the designer of *this* switch. "Young son had used up all the flashlight batteries at Scout camp. Horrible. Gave me the idea for a switch *anybody* could re-fuse. It works, too."

This insight into the limitations of the average American householder is now helping to swell demand for the 30-amp safety switch pictured here. As you can see, the crossbar that actuates the contact has been moved to the back where it cannot get in the way of fumbling fingers.

To accommodate the new design, a one-piece block of Durez phenolic supplants a two-piece porcelain block. The more compact block of Durez allows extra hand-room for wiring the switch, and weighs less without loss of performance.

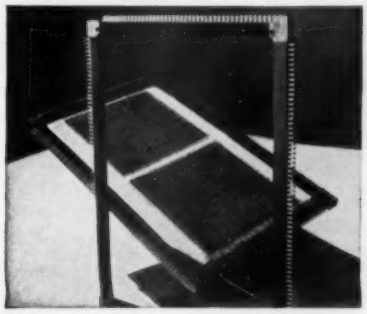
Have you an idea for a better electrical device? The odds are good that one of more than 200 Durez molding compounds can give it the exact mix of properties you want it to have. To narrow the uncertainty, see your molder or write us direct.

Jet-age abacus

With the help of Durez plastics, man can string words and numbers on wire like beads and pick them off again in millionths of a second.

His modern abacus is the IBM magnetic core memory. Thousands of tiny ferrite cores are wired into a frame like the one in the middle of this page. In an array of these core planes, stacked one atop another, electrical impulses alter the magnetic state of cores. A line of cores, some altered, some neutral, stands for a word or number, awaiting the impulse that releases it for calculation.

IBM engineers needed modern materials to bring this jet-age concept into being. The frame that supports the cores must be an excellent insulator. It must be free of internal stress that would cause warping or cracking. During assembly it must withstand the heat of dip soldering without losing its dimensions. Once assembled, it must not shrink or expand.



International Business Machines Corporation

For the core frame, designers and molder chose a mineral-filled Durez phenolic that delivers the ultimate in stability, heat resistance, dielectric strength, and moldability, meeting all requirements.

Other Durez phenolics prove their inborn versatility in the molded circuits of stepping switches, emitters, and zebra plates in new IBM accounting machines.

How much for a handle?

No, you don't really need a slide rule to design a coffeepot handle, but it helps.

This designer, at the moment, is not concerned at all with the compound-curve esthetics of coffeepot handles. He is simply figuring out how many handles his

molder can make out of 1,000 pounds of which molding compound, and for how little money.

With the slide rule, it takes him only three and a half minutes to learn that his best bet for *this* handle is likely to be *Durez 1308*. Of the many mineral-filled phenolics we make, this one is in the lower gravity range. More pieces per dollar.

He has already checked into *1308's* other traits: rich black surface, uniform luster, good heat resistance (it withstands 450°F for short periods), low water absorption, flexural and tensile strengths OK.

His molder confirms the choice, for different reasons: he can get *1308* in four different plasticities, can plunger mold it, and it cures fast. Looks as if another good product is off the ground.

You don't design handles? Well, *1308* appears to fit into more heat-resistant applications than any comparable material ever developed: appliance and meter housings, wiring devices, tube bases, sockets, coil forms. The list goes on and on. But we'll stop so you can talk to your molder about *1308* for that next hot-spot job.

For more information on Durez materials, check here:

- ☐ 8-page Bulletin D400 lists properties, uses, design advantages of Durez thermosetting compounds, Hetron fire-retardant polyester resins, and Durez phenolic bonding resins.
- ☐ **"Durez Plastics News,"** mailed periodically, shows and describes latest uses of Durez materials.

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

1408 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

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NEW! FIRE-

PROPERTIES OF PLASKON FIRE-RESISTANT UREA UFR-28:

MOLDING PROPERTIES	ASTM TEST METHOD	FIRE-RESISTANT UREA
Bulk Factor	D392-38	2.4-3.0
Preformability		Good
Temperature, F		275-325
Pressure		2,000-8,000
Mold Shrinkage, in/in		0.006-0.014

PROPERTIES MOLDED	ASTM TEST METHOD	FIRE-RESISTANT UREA
Electrical		
Arc Resistance, sec.	D495-58T	110-130
Dielectric Strength, v/mil	D149-55T	
Short time, ⅛ inch		300-400
Step-by-step, ⅛ inch		200-300

PHYSICAL	ASTM TEST METHOD	FIRE-RESISTANT UREA
Specific Gravity	D792-50	1.47-1.52
Coefficient of Linear Thermal Expansion/deg C, max.	D696-44	2.7×10^{5}
Thermal Conductivity, g-cal/(sec) (cm^2) (deg C/cm)		7.8×10^{4}
Heat Resistance, F, max.		170
Deflection Temperature under Load (Heat distortion), 264 psi, F	D648-56	245
Water Absorption, per cent, 24 hr @ 25 C	D570-42	0.5-0.7

RESISTANT UREA

PHOTO COURTESY OF UNDERWRITERS' LABORATORIES INC.

A.S.T.M. Test D635-56T
RATING: NON-BURNING

MECHANICAL	ASTM TEST METHOD	FIRE-RESISTANT UREA
Impact Strength		
Izod ft-lb/in. of notch	D256-56	0.25-0.35
Flexural Strength, psi	D790-58T	10,000-16,000
Tensile Strength, psi	D638-58T	5,000-10,000
Rockwell Hardness	D785-51	M116-M120

Plaskon Today, more and more emphasis is being placed on plastic material possessing high fire retardant characteristics. In response to this critical need, ALLIED CHEMICAL has developed a truly *FIRE-RESISTANT* Urea UFR-28. Where other white and pastel compounds may blister, crack, drip, sag, or readily contribute to flame spread—PLASKON Fire-Resistant Urea effectively meets stringent Underwriters' Laboratories requirements.

In products made of low fire retardant materials, the possibility of "hot spots" arising from overload, long use or any malfunction presents serious fire hazards. PLASKON Fire-Resistant Urea will combat such hazards. Fire-Resistant Urea continues to pass test after test requiring maximum safety. Whether it be a structural or non-structural component for today's products, look to ALLIED CHEMICAL for the thoroughly qualified fire-resistant thermoset compound—Fire-Resistant PLASKON Urea UFR-28 Molding Compound.

AND LOOK AT UFR-28's OTHER IMPORTANT PROPERTIES:

- High dielectric strength
- Non-static dust attraction
- Resistance to detergents
- Photometrically controlled color
- Self-supporting rigidity
- Ease of cleaning
- Hard surface, non-abrasion.

PLASKON Engineering know-how is at your service with technical assistance and experience acquired through years of problem solving. A phone call or letter is all it takes . . . do it TODAY!

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.
BASIC TO AMERICA'S PROGRESS

Allied Chemical

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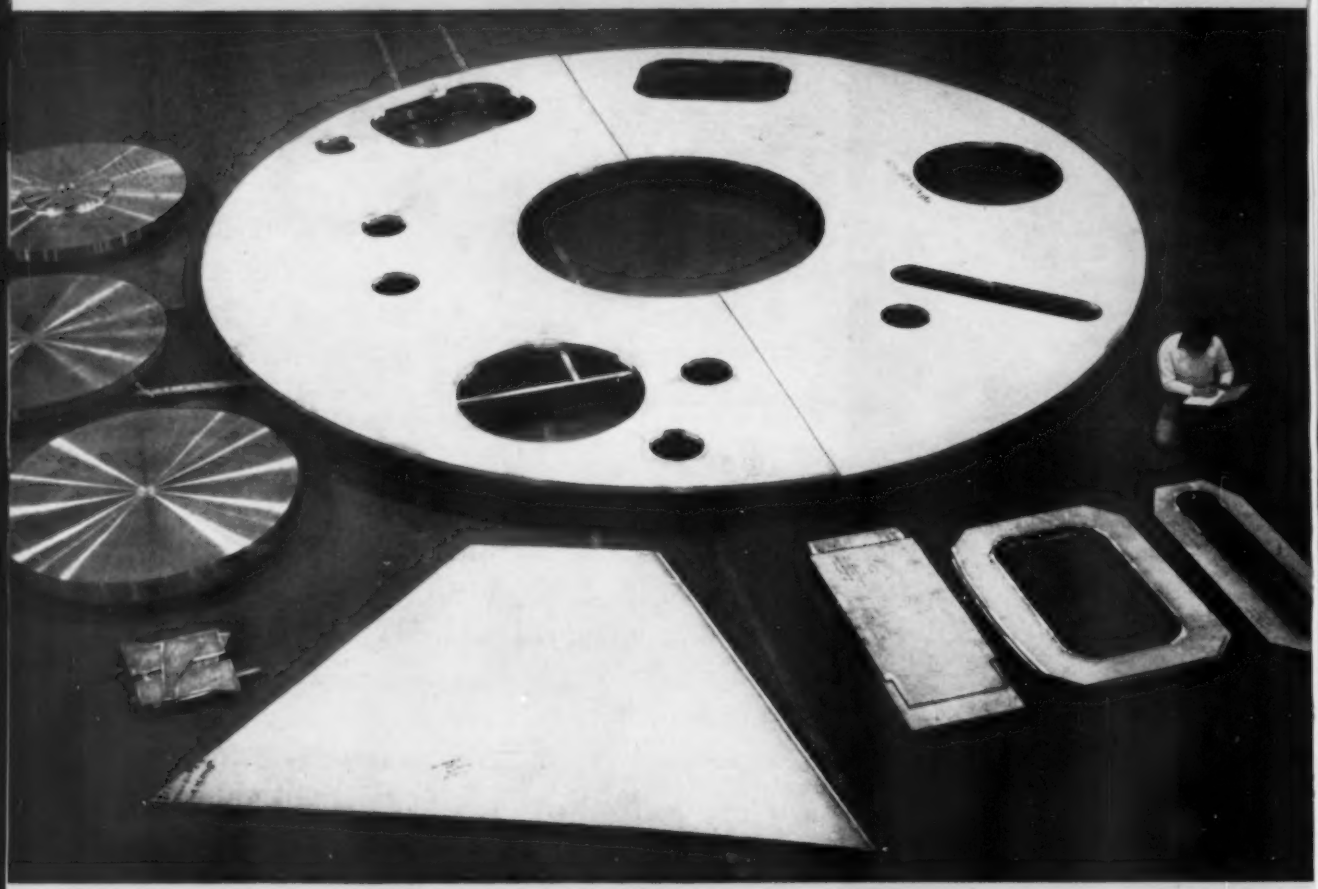
final check

on your order for stainless steel plate from Carlson



• **Stainless steel is our only business—and we know it!** Producing to your specified tolerances in shearing, sawing, abrasive cutting, flame cutting, forming and machining stainless steel plate is a regular Carlson service. This accuracy in manufacturing saves time and money in your shop. Fabrication is easier; true-up time is cut to a minimum.

This dependable service makes Carlson a money-saving source of supply for all your stainless steel plate. You run no risk of errors which increase your costs and jeopardize your reputation and good will with your customers.

Prompt, effective service starts the moment your inquiry reaches our office. The final check of your order is done by Carlson specialists for we know your satisfaction begins right here. Take advantage of our long experience in the field. Write today, your inquiry will receive prompt attention.

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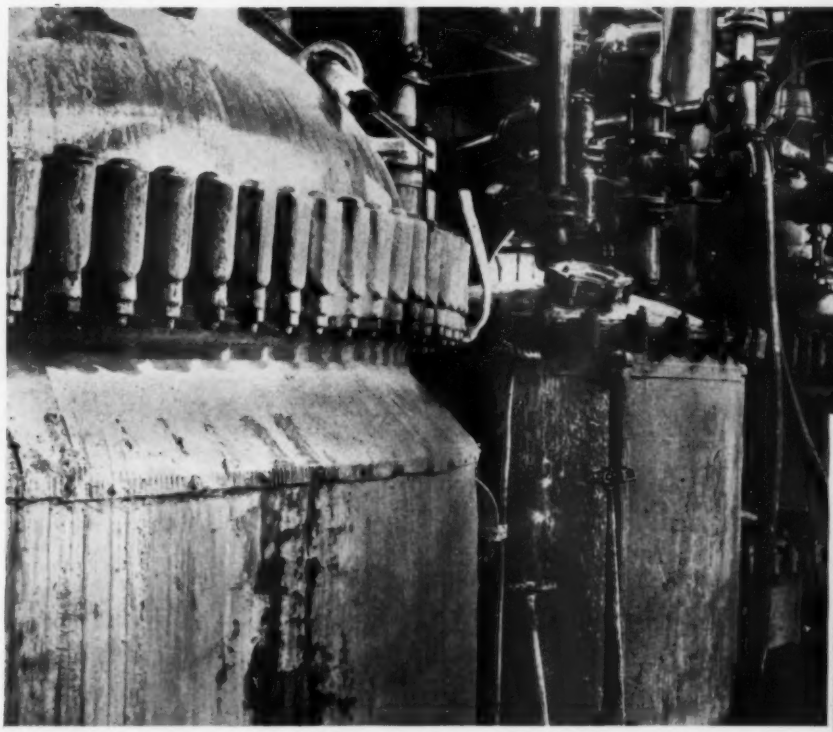
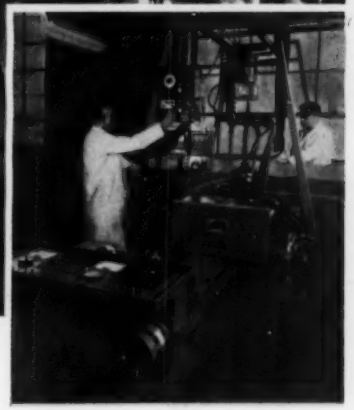
Witco Plant Controls Bring You The Most Uniform

RESINS FOR URETHANE FOAMS





Why do more and more manufacturers turn to Fomrez® resins for rigid and flexible urethane foam production?

Because WITCO FOMREZ resins assure batch-to-batch uniformity of your foam production. Their easy handling characteristics and high reproducibility reduce your production budget.

There's no compromise on quality with Witco. Up-to-date instrumentation guards high manufacturing standards. Quality is controlled at every production stage.

Send today for details of Witco Fomrez Resins. Just fill out and mail the coupon.

FOR FLEXIBLE FOAMS: *Fomrez 50 and Fomrez 70* • For use in furniture cushioning and upholstering; automotive seating, crash pads and headliners; garment interliners and shoulder pads.

FOR RIGID FOAMS: *Fomrez R-400 and Fomrez P-420* • A prepolymer foaming system for carbon dioxide or Freon blowing. Used in refrigerators and other cold-storage equipment; for structural reinforcement in sandwich panel construction; vibration dampening in aircraft and automobiles; marine flotation; and potting compounds.

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I am interested in: ☐ Fomrez 50 and Fomrez 70 for flexible foams
☐ Fomrez R-400 and Fomrez P-420 for rigid foams

Please send ☐ literature ☐ sample. The application I have in mind is_____

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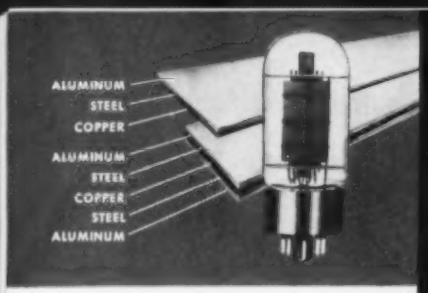

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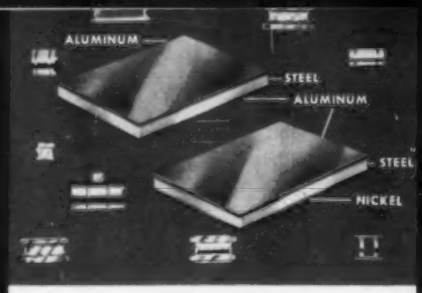
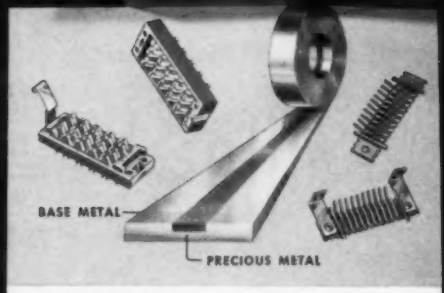
Three-layer and five-layer materials used for anodes in rectifier and amplifier tubes. Provide longer power output life . . . uniform heat dissipation . . . high electrical conductivity . . . improved anode reradiation . . . and reduce costs.



ALNIFER®, NIFER®

These clad metals are used as alternate materials for solid pure nickel in electron tubes. They conserve critical material . . . reduce costs substantially. Supplied in annealed coils ready for your production.



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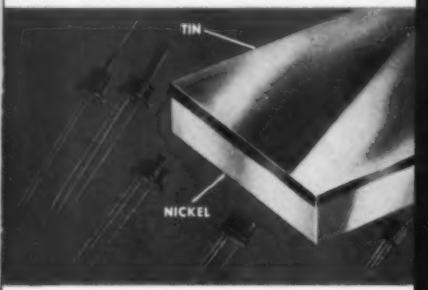
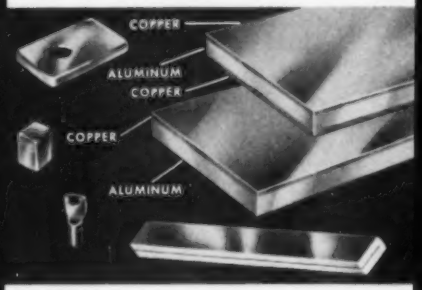
High reliability of connectors, clips, terminals obtained by using gold and other precious metal alloy stripe materials . . . place high performance materials in the contact areas . . . cost-savings and improved performance over gold electroplated parts.



TIN CLAD METAL STRIP and other Semiconductor Clad Metals

A number of combinations of clad metals are available for use on base tabs, lead wires, whisker wires, base materials and enclosures in silicon and germanium diodes, transistors and germanium power transistors.



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Easily formed, deep drawn or spun. Used for waveguides, component cases, variable condenser blades, chassis and electrical or thermal conductive parts. Light in weight, saves up to 30% over the cost of solid copper.

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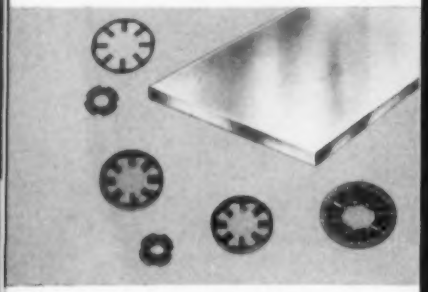
Featuring a sound metallurgical bond, these wires give three times greater conductivity than solid 52 alloy wire of equal diameter . . . they facilitate miniaturization. Features include: leakproof seal between alloy and core, high electrical and thermal conductivity, lower costs.



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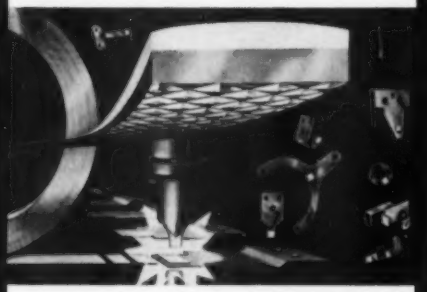
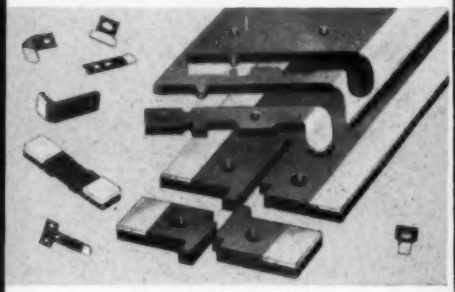
For magnetic applications requiring low core losses and high permeability at low flux densities in current and pulse transformers, relays, gyro mechanisms, servo mechanisms, missile guidance systems, etc.



CLAD ELECTRICAL CONTACT TAPES

For products you want to automate, this modern contact form permits greater latitude in contact assembly design . . . automatic assembly of two or more parts in a single operation. Tape contacts are easily attached by spot welding . . . are self-aligning . . . and allow broader assembly tolerances. Save up to 40% in contact costs.



CLAD CONTACT MATERIALS

Single and double inlay, overlay and toplay provide better electrical performance, longer operating life and lower fabrication costs. Complete assemblies can be made to close tolerances by single blanking and forming operations.

General Plate Clad Metals and Clad Electrical Contact Materials Solve Design Problems... Provide High Performance Reliability

General Plate clad precious-to-base or base-to-base metals are inseparably bonded by a patented solid-phase bonding process without the use of brazing alloys or other intermediate material.

If you are seeking metals with useful characteristics that can't be found in a single metal or alloy, investigate clad metals. If you want stronger or lighter components — or better electrical and mechanical properties — or fewer corrosion problems — or if you are interested in conserving critical metals or reducing parts costs, you can profit by using General Plate Clad Metals.

Write for a General Plate Clad Base Metals catalog today. Or better yet, why not talk over your requirements with a competent field engineer? His knowledge of the applications of clad metals is yours for the asking. No obligation, of course.

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A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

GENERAL PLATE PRODUCTS: Clad Metals • Electrical Contacts • Truflex® Thermostat Metal
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Insulate to 2000° F. with REFRASIL

This may be the SPECIAL INSULATION you're looking for!

REFRASIL PHYSICAL PROPERTIES:

- Chemical resistance of pure silica
- Resists temperatures up to 3000° F. under certain conditions
- Low Thermal conductivity
- Fiber diameter .00020-.00040 in.
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- Surface density .05 lb./sq. ft. (Batt)

REFRASIL USES:

- 2000° F. continuous high temp. insulation
- Filtration of corrosive materials
- Removable, insulating blankets
- REFRASIL Reinforced Plastics (ASTROLITE for up to 15,000° for short duration)
- Thermocouple wire insulation
- Electric muffle furnaces
- Laboratory heating mantles

If you're looking for an efficient, lightweight 2000°-3000°F. insulating material in any of the physical forms shown above, REFRASIL may be your best answer.

Long proven for jet aircraft and missile use, REFRASIL is fast becoming an important industrial insulation for −300°F. cold to +3000°F. heat.

When other insulation materials fail in critical high temperature use, write or call for test samples of REFRASIL. It may be the *special* insulation you're looking for!

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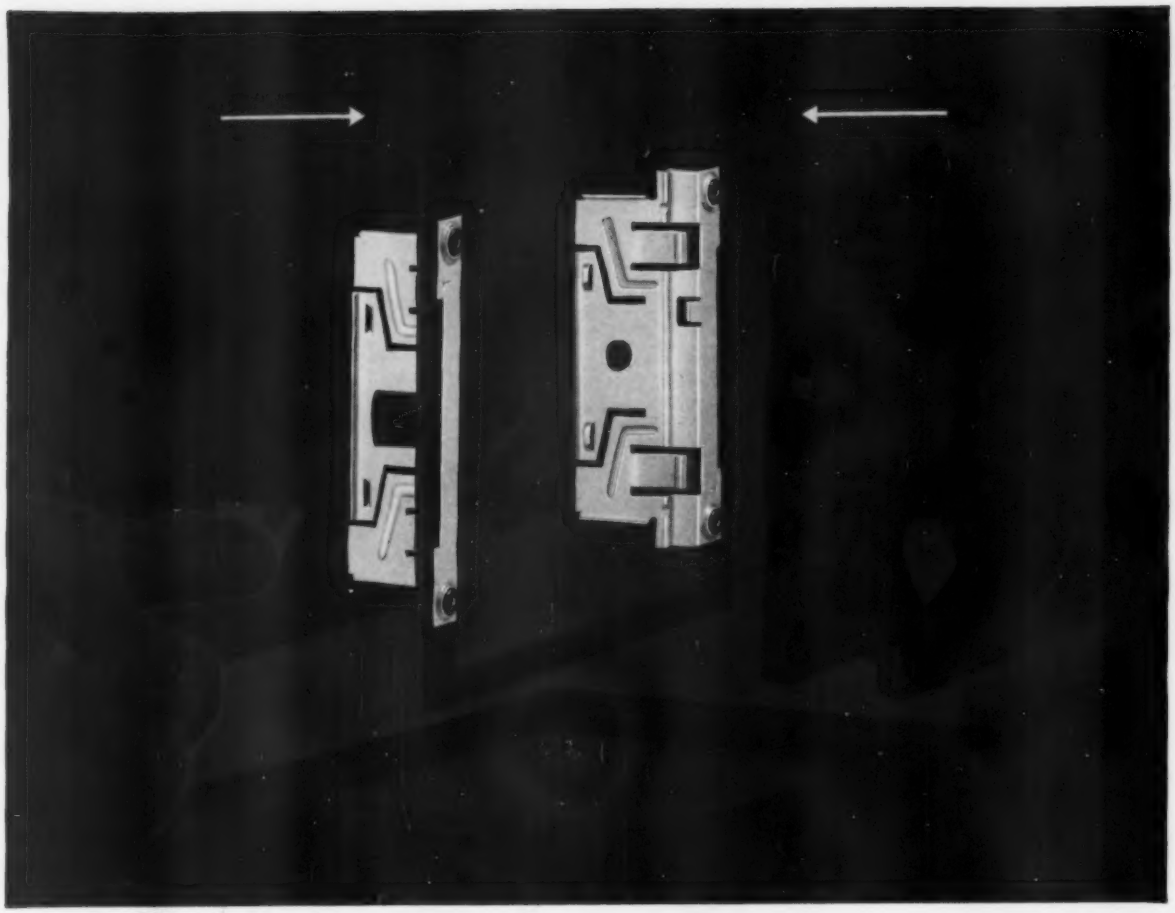

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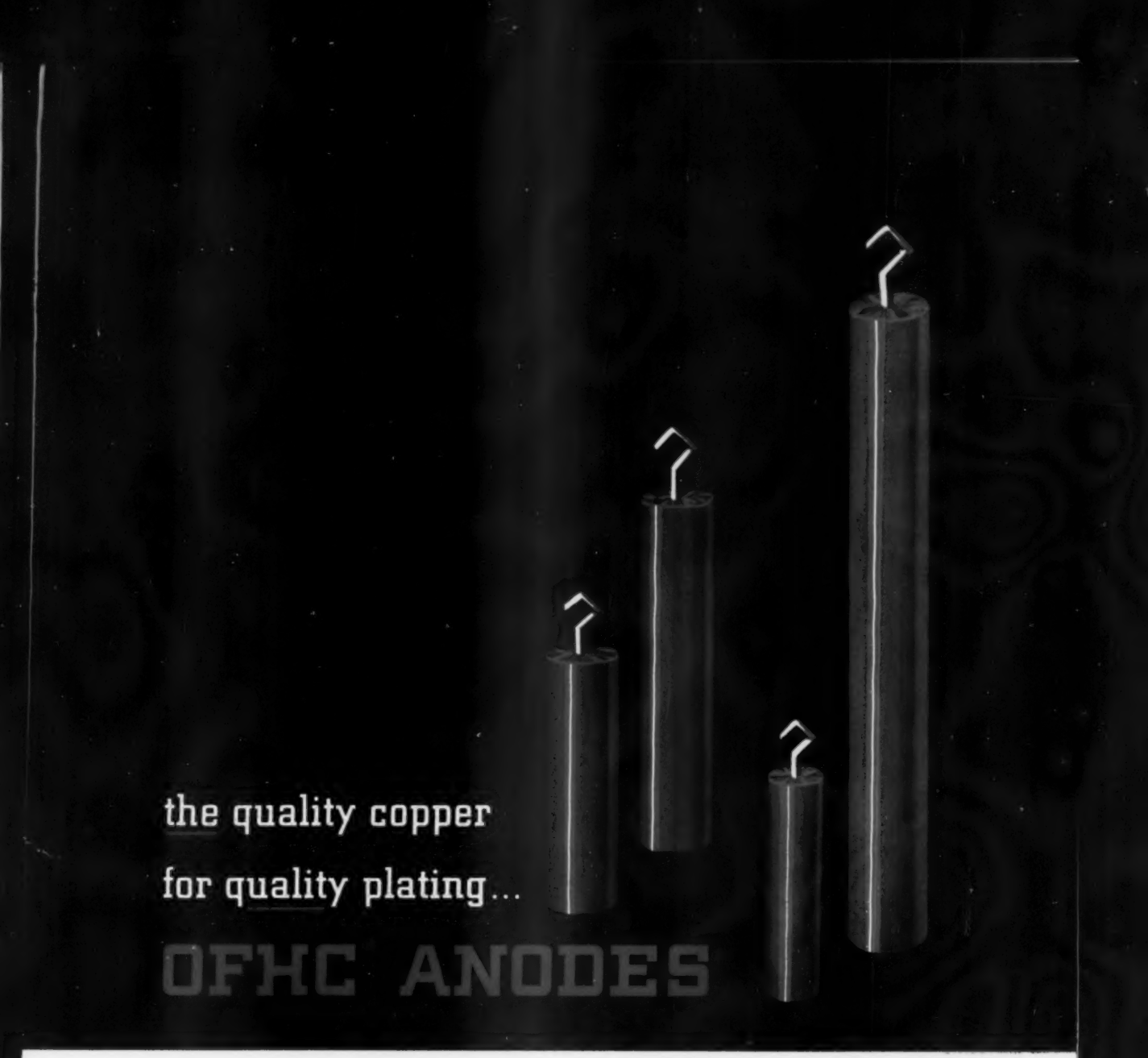

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OFHC Anodes—Made Only by American Metal Climax—are Sold by Leading Plating-Supply Distributors Everywhere.

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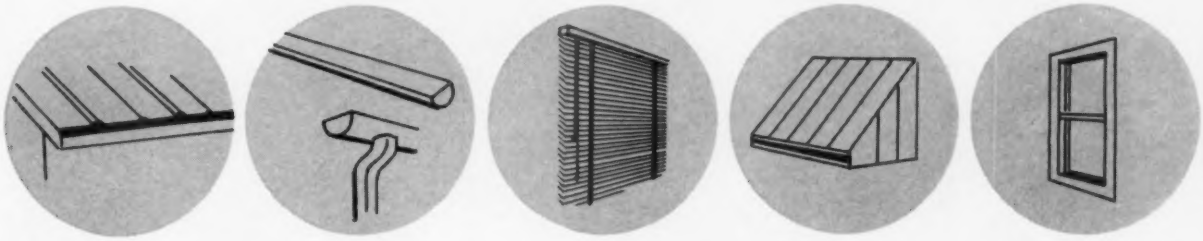
makes your painted products look better longer



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Bonderite on aluminum means fine appearance longer, because it controls corrosion and anchors the paint.

Bonderized and painted aluminum is produced on automated strip lines in which the metal is cleaned, Bonderized and painted, then re-coiled ready for use.

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Many Applications of Bonderite for Aluminum

There's more than one type of Bonderite for use on aluminum. In wide use is Bonderite as a base for paint, which adds durability and long life to paint finishes on so many aluminum products.

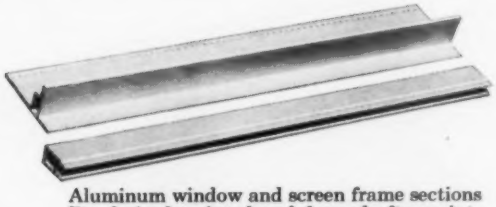
Another Bonderite produces an attractive green coating, used on many architectural products without further finish.

Protection without changing the characteristic color of the metal is provided by another Bonderite.

There is also a Bonderite, formulated for mixed production, which coats aluminum, steel and zinc.

Bonderite for aluminum meets and exceeds the requirements of Government Specification MIL-C-5541.

Well over two hundred plants—large, medium-sized and small—use these great Parker products on their aluminum production. Better investigate for *your* plant, today!



Aluminum window and screen frame sections Bonderized, painted and formed after painting. No breaks in finish anywhere! (Courtesy, Security Co., Detroit, Mich.)

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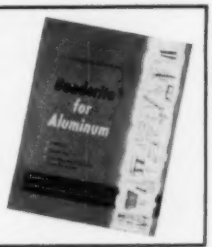

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BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

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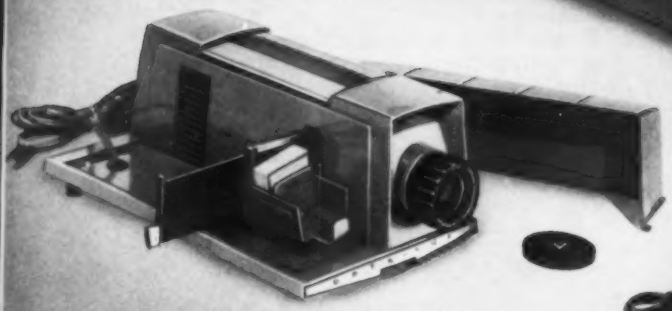
NEW DESIGNS IN MARLEX

Optics Mfg. offers new line of



This is the semi-automatic model of the Opta-Matic projector, using a 300-watt bulb and 4-inch f3.5 Opta-cor coated projection lens. With this new lightweight, unbreakable, heat-resistant MARLEX case, the whole unit weighs only slightly more than 6 lb. The special "Riviera Blue" color of the case is molded into the MARLEX . . . will never fade or discolor. And the attractive textured finish is resistant to marring and stains.

This fully automatic model of the projector can be operated either with the push buttons on the motor or the remote control cord, or with a built-in 8-second timer. The removable section of the black textured finish MARLEX housing snaps into place making a neat, fully enclosed unit, easily carried by the disappearing handle. MARLEX was also specified for the height adjustment knob on these projectors. MARLEX is excellent for these precision molded components, having superior toughness, abrasion-resistance and self-lubricating qualities.

slide projectors with cases made of

MARLEX*

The first major photographic application for rigid polyethylene!

"We picked MARLEX for our new slide projector case and height adjustment knob because it is the least expensive type of plastic material that has the required rigidity, resistance to heat and impact, colorability and gloss," says Herbert R. Leopold, Vice President of Optics Manufacturing Corp., Philadelphia, Pa.

"Our new Opta-Matic is the first projector on the market with a thermoplastic housing. Since this was a design innovation, we had to be sure to select a suitable resin, so we tested them all. One 'high-impact' plastic lasted just 4 hours in our heat test before it melted! Another 'heat-resistant' plastic cracked in several places in our drop test. MARLEX was the only material tested that matched all our specifications and passed all our tests. In fact, we advertise a lifetime guarantee for all MARLEX projector components!"

Whether your major interest is designing with injection moldings, thermo-formings, extrusions, filaments, sheet or transparent film, you will find that MARLEX is the best thermoplastic resin for the job. In fact, no other material serves so well, and so economically in so many different applications. How can MARLEX serve you?

*MARLEX is a trademark for Phillips family of olefin polymers.

These beautifully styled Opta-Matic projectors were designed by James H. Parcher of Leotta & Parcher, a leading industrial design firm in Philadelphia, Pa. This is actually the first slide projector ever designed specifically to use a plastic housing, and the first important use of rigid polyethylene in the photographic industry.

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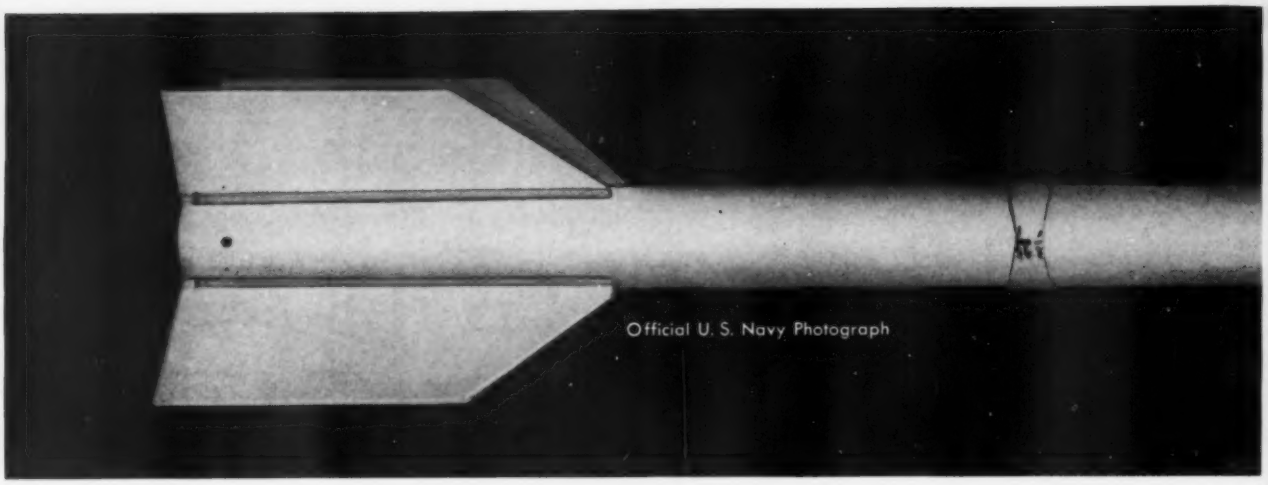
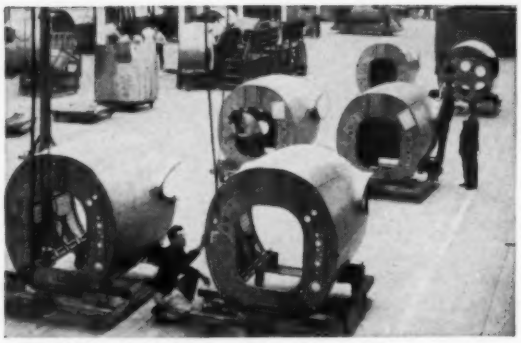


REPUBLIC TITANIUM is used in dozens of structural components and details in the Martin P6M SeaMaster, including engine nacelle center beams such as the one illustrated. Commercially pure titanium and titanium alloys supplied by Republic increase strength and heat resistance, reduce weight. Republic Titanium Alloys are among the strongest produced, offer exceptionally high strength values at elevated temperatures.

REPUBLIC'S NEW, TYPE HS6460 METAL POWDER is ideal for sinterings of highly stressed components in aircraft and missiles. Provides minimum tensile strength of 60,000 psi at 6.4 density as sintered . . . 100,000 psi after heat treatment. Less than .004% shrinkage from die size at 6.4 density. Available in quantities up to and including 12 tons or multiples. Can be used with existing operating equipment. Mail coupon for technical data sheet.



REPUBLIC ENDURO® STAINLESS STEELS—types 301 and 302—are currently being used by Solar Aircraft Company in the fabrication of complete engine nacelles for Navy P2V patrol bombers. Stainless construction offers greater strength, permits use of lighter gages, increases corrosion and high temperature resistance. All types are readily formed into desired shapes by the usual commercial methods. Send coupon for complete information.

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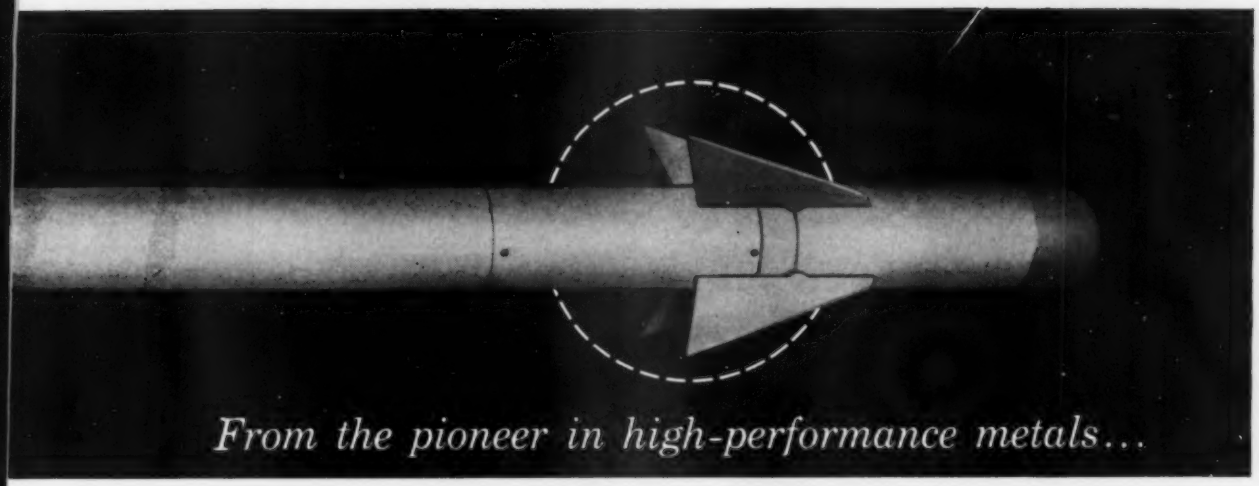


From the pioneer in high-performance metals...

TYPE 4130 ALLOY STEEL FINS FOR THE SIDEWINDER

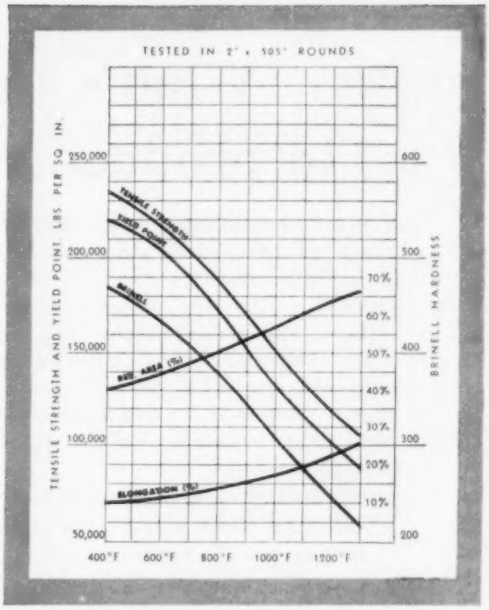
Close-tolerance, delicately contoured fins for the Sidewinder air-to-air missile are currently being produced from Republic Type 4130 Alloy Steel by the Storms Drop Forging Company, Springfield, Massachusetts. Choice of this high-strength alloy, according to Storms, was dictated by extreme performance requirements.

Republic 4130 offers exceptionally high strength-to-weight ratios with the highest strength values. As seen at right, tensile strength in the heat-treated condition is over 230,000 psi after tempering at 400°F., with a Brinell Hardness of 460. Uniform response to heat treatment assures complete deep-hardening penetration.

The Storms Drop Forging Company reports no production difficulties involved in the use of Republic 4130. Fins are produced from hot-rolled 1½" diameter 4130 bars in successive forging, hot trimming, grinding, wet tumbling, and coining operations.

Republic has pioneered in the development and production of new metals to resist heat, reduce weight, or increase strength. With constantly expanding research as well as production facilities and capabilities, Republic stands as the nation's largest producer of *high-performance* metals—titanium, stainless, and alloy steels.

Let us help you find the most advantageous use of these metals in *your* project. Return the coupon for complete information without obligation. Please indicate if you would like a Republic Metallurgical Specialist to call.



TYPE 4130

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STEEL

Stainless Steel, and Alloy Steel

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What's the lowest cost way to produce steel parts like these?

You may be paying considerably more than you need to for parts like these if you aren't taking advantage of Ryerson flame-cutting service.

Size makes no difference—nor intricacy of shape. You can order one part or one thousand and get quick delivery of steel cut to close tolerance—with almost die-cut accuracy from piece to piece. And here's where the saving comes in:

1. **No dies or molds** are needed so you save this cost when you switch from cast or forged parts to flame-cut parts.
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You draw on the nation's largest steel stocks at Ryerson—and unequalled flame-cutting facilities are ready to work for you. A blue print or sketch with clearly marked dimensions is all we need for prompt handling of your requirements. Call your nearby Ryerson plant for cost-cutting flame-cut steel today.

In stock: Carbon, alloy and stainless steel—bars, structurals, plates, sheets and strip, tubing, re-bars—industrial plastics, machinery & tools, etc.

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Miniature Precision Bearings, Inc.

Precision bearings *for critical applications are produced from vacuum melted 52100 steel.*

Vacuum Melted Metals and Alloys

—Why Use Them?

You may get added toughness and uniformity that are worth the price. And some useful alloys must be made by vacuum melting. Here is a helpful status report.

by John L. Everhart, *Technical Editor, Materials in Design Engineering*.*

■ Vacuum melted alloys are cleaner and contain less gaseous impurities than air melted alloys. This increased freedom from inclusions, in turn, increases the uniformity of the material and may enhance the properties. Whether the improvement is worth the additional cost depends on the application.

In general, there is little improvement in such properties as tensile strength and hardness as a result of melting in vacuum. On the other hand, ductility, impact strength, fatigue strength and rupture properties, which are sensitive to structural variations, can sometimes be improved by vacuum melting.

Two commercial methods of vacuum melting are in use at present. They are 1) vacuum induction melting, and 2) consumable-electrode-arc vacuum melting, usually called vacuum arc melting. In addition, there is another process which, while not strictly vacuum melting, is industrially important and performs some of the functions of vacuum melting. This is vacuum degassing, performed by pouring from a conventional furnace into a mold placed in a vacuum chamber. This process is discussed separately. Some of the characteristics of the three proc-

* Now associated with International Nickel Co.

TABLE 1—CHARACTERISTICS RESULTING FROM VARIOUS MELTING PROCESSES

Process ↓	Melting Characteristics			Product Characteristics				
	Temp, F	Pressure	Time Metal Molten, hr	Hot Workability	Gas Content, ppm	Cleanliness	Segregation	Mechanical Properties
Air Melting	2500-3100	1 atm	2-3	Poor to fair	H_2 4-20, O_2 10-150, N_2 30-500	Fair	Normal	Normal
Vacuum Degassing	2500-3100	Melting, 1 atm; degassing, 0.5-10 mm	½-4	Fair to good	H_2 1-4, O_2 10-60, N_2 40-120	Fair to clean	Normal	Improved 5-50%
Vacuum Induction	2500-3100	1-100μ	1-5	Fair to good	H_2<1, O_2 4-10 N_2 3-50	Very clean	Normal	Improved 20-200%
Vacuum Arc (from air melted stock)	2500-8500	5-500μ	¼-½	Good	H_2 1-2, O_2 6-30, N_2 40-100	Clean	Relatively free	Improved 10-100%
Vacuum Arc (from vacuum induction stock)	2500-8500	5-500μ	¼-½	Very good	H_2<1, O_2 1-5, N_2 2-20	Extremely clean	Relatively free	Improved 30-300%

Source: *Aksoy.*

esses are compared with those of conventional processes in Table 1.

The cost

The cost of vacuum melting is high by normal steel melting standards. However, the yield is more influential in determining alloy costs than the melting cost and it is impossible to give a good cost figure for vacuum melting unless it is known whether the yield of saleable product is increased.

An indication of the relative costs of conventional and vacuum melting can be obtained from the following data, however: It has been reported that low alloy and tool steels will carry a premium of $2.00 to $2.50 per lb if vacuum induction melted and $0.50 to $1.00 per lb if vacuum arc melted. Similarly, superalloys will carry a premium of $1.00 per lb if vacuum induction melted and $0.25 per lb if vacuum arc melted.

The advantage of vacuum melting must be weighed for each alloy and each application. There is no justification for vacuum melting an alloy if conventionally melted material will serve satisfactorily in a given application. On the other hand, some alloys can be produced only by vacuum melting.

What does vacuum melting actually do?

Some attributes of the two commercial vacuum melting procedures are discussed briefly in a box on p 91. Essentially the two procedures perform the same functions:

1. Dissolved gases are removed.
2. Volatile impurities may be removed.
3. Reaction between constituents may be prevented by removal of gaseous by-products.
4. Nonmetallic impurities, particularly oxides, can be prevented from forming.
5. Effectiveness of valuable constituents such as aluminum and titanium can be maintained by avoiding formation of compounds such as oxides, nitrides, etc.

Removal of gases and compounds—The principal value to be obtained by vacuum melting is the removal of gases. In general, the solubility of a gas in a metal increases with the temperature, and gases are much more soluble in liquid than in solid metals. The physical solubility of a gas in a metal is practically zero in the solid state. Thus, gas that cannot escape during freezing is liberated within the metal, forming porosity or blow holes. Gas can also react with the metal to form compounds, such as oxides. These compounds are usually insoluble in the metal and can have a detrimental effect on its properties.

Gases which are dissolved in the metal can be removed by melting and solidifying under a suitable vacuum. Some compounds can be removed also, because they decompose at the melting point and the liberated gas can be pumped off. For example, oxygen in copper, which is present as cuprous oxide, can be removed completely by vacuum melting.

On the other hand, some of the more refractory compounds cannot be decomposed by vacuum treatment; these include aluminum, chromium and titanium oxides. Sometimes they can be removed by holding the metal molten under a vacuum for sufficient time to permit them to float to the surface of the bath.

As a result of gas and compound removal, vacuum melting improves the cleanliness of the material. The greatly reduced inclusion content of 52100 steel after vacuum melting results in increased bearing life for this material. This control of cleanliness is possible with other materials also, but not in all compositions; the high manganese and silicon contents of low alloy steels, with resulting large inclusion content, make it extremely difficult to obtain a high degree of cleanliness through vacuum melting.

Uniformity—An important by-

product of the increased cleanliness of vacuum melted alloys is the high degree of uniformity that results from heat to heat. Some of this improvement may be the result of using purer raw materials, but most is the result of the elimination of variables that occur in air melting. Uniformity permits the designer to reduce his factor of safety which must be based on the lowest value to be expected rather than on the average.

Economics—On the economic side certain factors must be considered. For example, is it more economical to use a pure feed stock or to use an impure stock and increase the refining cycle?

Another factor is the degree of degassing required. There is still a great deal of work required to determine how much gas can remain in the metal without detriment to the properties. In some cases, purification beyond a certain limit may greatly increase manufacturing cost with only a slight improvement in properties.

As a corollary to these two points, there is another consideration. Would the melting of highly purified materials in a conventional arc furnace yield alloys having properties sufficiently close to those of vacuum melted alloys to eliminate the need for vacuum melting. If so, it may be possible to reduce costs considerably by using conventional furnaces for some alloys. Of course, this possibility would apply only to alloys which can be air melted.

What materials are vacuum melted?

Practically any alloy can be vacuum melted and a great number have been prepared on an experimental basis. Whether they will ever reach commercial production depends on the degree of improvement resulting from the process.

Improvements from vacuum melting can be considered under two categories:

1. Materials that can be processed by conventional methods. In materials of this kind, any improvement can be attributed to the process.

2. Materials that require vacuum melting because of their compositions. Improvements offered by such materials are the direct result of changes in composition permitted by use of the vacuum melt-

Vacuum Melting: The Two Processes

The two commercial vacuum melting procedures in use at present are: 1) vacuum induction melting, and 2) vacuum arc melting. Their characteristics are compared with those of other melting processes in Table 1 and discussed briefly below.

Vacuum induction melting

The vacuum induction furnace differs from atmosphere furnaces only in its operating pressure. Temperatures and working of the melt are identical in both operations.

The benefits to be derived from vacuum induction melting are:

1. Control of composition which, in turn, gives greater uniformity in the properties of the alloy.
2. Modification of composition that results in greater creep strength.
3. Reduction of harmful inclusions, which improves forgeability.

Ingot structure is not improved by vacuum induction melting.

One disadvantage of vacuum induction melting is crucible contamination; rate of attack on the refractory by carbon is intensified at low pressures. In the vacuum melting of M-252 it has been shown that attack on the refractory can result in sufficient pick-up of boron and zirconium to significantly affect the high temperature properties. Although this discovery was beneficial since it led to the addition of controlled quantities of boron and zirconium with a corresponding improvement in high temperature properties, contamination from the crucible might be detrimental in other alloys.

Induction vacuum melting has two serious cost disadvantages: small capacity and low melting rates. In addition, installation costs are higher than for either vacuum arc melting or vacuum pouring. Many authorities believe that electrical and mechanical problems will limit the size of vacuum induction furnaces to a maximum of 5000 lb capacity.

Vacuum arc melting

Vacuum arc melting can be considered as similar to consumable electrode arc welding. In exactly the same manner as in welding, the stock is carried across the arc and deposited in a pool below. However, the metal is collected in a water-cooled copper mold.

The outstanding feature of this process is its ability to produce an exceptionally sound ingot by controlled solidification. It is possible to produce homogeneous ingots up to at least 20 in. in dia by vacuum arc melting. Actually, the major function of the vacuum is to protect the melt from oxidation.

However, considerable degassification occurs also because the pool of molten metal is quite deep and permits a fairly long reaction time during which some dissociation of oxides and nitrides can occur. Vacuum arc melting of alloys such as Waspaloy, M-252 and A-286 reduces hydrogen, nitrogen and oxygen by at least 60%, and in some cases up to 94%, according to some investigators. Greater purification is possible in carbon and low alloy steels than in high temperature metals because of the relatively greater instability of the nonmetallic inclusions. It is also possible to levitate some of the compounds that do not dissociate, although they generally freeze on the crucible walls and can be removed by subsequent ingot conditioning.

Vacuum arc melting does not provide all the desired improvements in an alloy. It improves forgeability and produces a better ingot structure. However, use of air melted electrodes limits the control of chemistry to that achievable in air melting. To obtain optimum high temperature properties of special alloys electrodes produced by vacuum induction melting must be used. This requirement is the major disadvantage of the process.

ing furnace.

Materials that can be produced either by conventional or vacuum processes include the usual alloy steels, stainless steels, tool steels, many specialty steels and some of the superalloys. How great a factor vacuum melting will be in the production of these materials is a matter of considerable disagreement. For example, some tool steel producers believe that all hot work tool steels will be produced by vacuum arc melting within a few years; others believe that this process will be used only for tool steels intended for specialty applications such as high temperature bearings.

With the alloy steels, such as 4340, the high premium asked for vacuum melted material will certainly limit its use to critical applications. Most applications will probably continue to be served by conventionally melted stock. This probability also holds for stainless steels. However, the superalloys may eventually be produced by vacuum melting because of their severe service requirements.

A factor that may limit growth of vacuum melting is the considerable probability that vacuum degassing will be used extensively in the future. The process is relatively inexpensive and is applicable to conventional melting equipment handling large tonnages.

On the other hand, the second group of materials—alloys that are vacuum melted because of their composition—*must* be vacuum melted. These materials include many of the nickel, cobalt or iron-base superalloys which contain reactive elements such as titanium, aluminum, boron and zirconium in quantities sufficiently great to make it difficult to obtain uniform compositions and properties by conventional melting methods. The group also includes alloys such as alfenol that are not workable when cast in air but are workable after vacuum casting. Of course, this group also includes materials such as titanium, zirconium and similar highly reactive metals that must be handled in a vacuum.

An idea of the applications of the various vacuum processes is given in Table 2. The number of alloys that can be or have been produced in commercial or semi-commercial quantities is large and no useful purpose would be served in listing them. An idea of the extent can be obtained from a recent compilation of producers and products by *Metal Progress*, published in August, 1958. This list included 21 nickel-base superalloys, 6 iron-

TABLE 2—APPLICATIONS OF VACUUM DEGASSING AND MELTING

Proved Applications	Small Scale or Experimental Applications
VACUUM DEGASSING	
Turbine rotors Generator rotors Propeller shafts Backing rolls High pressure casings	Tools and dies
VACUUM INDUCTION MELTING	
Atomic energy (U, Pu alloys) Jet engines and gas turbines: turbine buckets and disks Bearings Electrical and resistance heating elements Tools and dies Electronics Magnetics	High boron stainless steel Stainless steel to resist stress corrosion Low alloy steel to resist temper embrittlement Glass-to-metal seals Jewelers' rolls
VACUUM ARC MELTING	
Jet engines and gas turbines: turbine disks, buckets, casings Bearings Refractory and reactive metals: Ti, Zr, Mo, Cb, W, U, Pu, Rh, Yt, and others	Compressor blading

Source: *Evans.*

TABLE 3—NOMINAL COMPOSITION OF ALLOYS MENTIONED (%)

Alloy	C	Cr	Ni	Co	Fe	Mo	Ti	Al	Other
NICKEL-BASE SUPERALLOYS									
Waspaloy	0.08	19.5	Bal	13.5	1.0	4.25	3.0	1.3	Zr 0.06, B 0.005
Udimet 500	0.10	19.0	Bal	19.0	—	4.0	3.0	3.0	—
M-252	0.15	19.0	Bal	10.0	1.25	9.75	2.5	1.1	Zr 0.06, B 0.005
René 41	0.12	19.0	Bal	11.0	—	9.75	3.2	1.6	B 0.006
GMR-235	0.15	16.0	Bal	—	10.0	5.3	2.2	3.2	B 0.075
GMR-235D	0.15	15.5	Bal	—	4.25	5.25	2.5	3.6	B 0.075
R-235	0.16	15.5	Bal	2.5	10.0	5.5	2.5	2.0	—
COBALT-BASE SUPERALLOYS									
X-40	—	23.0	10.0	Bal	—	—	—	—	W 7.0
IRON-BASE SUPERALLOYS									
A-286	0.06	14.8	25.5	—	Bal	1.3	2.0	—	V 0.3, B 0.003
Discaloy	0.06	13.5	26.0	—	Bal	3.0	1.7	—	—
W-545	0.05	13.5	26.0	—	Bal	1.5	2.85	0.20	B 0.08
IRONS AND STEELS									
4340	0.40	0.80	1.8	—	Bal	0.25	—	—	—
6150	0.50	1.00	—	—	Bal	—	—	—	V 0.20
52100	1.00	1.50	—	—	Bal	—	—	—	—
Ni-V-Mo	0.25	—	2.85	—	Bal	0.50	—	—	V 0.07
VascoJet 1000	0.4	5.0	—	—	Bal	1.3	—	—	V 0.5
UHS-260	0.35	1.25	—	—	Bal	0.35	—	—	V 0.2, Si 1.85
Thermanol	0.03	—	—	—	Bal	3.3	—	15.4	—
Alfenol	0.01	—	—	—	Bal	—	—	15.8	—
430	<0.12	16	—	—	Bal	—	—	—	—
446	0.20	25	—	—	Bal	—	—	—	N 0.25

base superalloys, 4 cobalt-base superalloys, 12 alloy tool steels, 16 stainless and heat resisting steels, and 30 miscellaneous steels.

Compositions of the materials mentioned in this article are given in Table 3.

How vacuum melting affects properties

The properties of vacuum melted alloys differ from those of air melted materials because of the effect of the vacuum on dissolved gases or on gases formed by thermal dissociation or chemical reaction. By removing these gases from the melt, the process generally yields a steel having a greatly reduced inclusion content.

Structurally sensitive properties are affected by the nature, quantity and distribution of impurities. These properties include ductility, fatigue strength, impact strength, and such magnetic properties as permeability, coercive force and hysteresis losses. Structurally insensitive properties such as tensile strength show little change.

Although there is a difference of opinion among various producers as to the relative merits of vacuum induction and vacuum arc melting, the two processes perform essentially the same function. Therefore the properties of vacuum melted alloys should be similar regardless of which method is used in producing them and no distinction will be made here.

No attempt has been made in this article to include the properties of all available alloys. Instead, examples have been selected to point up characteristic differences and similarities between vacuum and air melted materials.

Haynes Stellite Co.

Axial flow power wheel *for a gas turbine is a typical application of vacuum melted superalloys.*

. . . at room temperature

A characteristic of many conventionally-melted wrought materials is anisotropy, i.e., a difference in the properties in the longitudinal and transverse directions. A cause of this anisotropy is elongation of the inclusions during primary working, and it is impossible to remove the effect by subsequent heat treatment. If inclusions could be completely eliminated, it should be possible to produce a completely isotropic material. This ideal condition cannot be realized in practice, but limitations of inclusions can be achieved during vacuum melting to a greater degree than in air melting.

▶ Table 4 shows the longitudinal and transverse properties of a number of materials after air and vacuum melting. The tensile and yield strengths of the air melted materials are practically the same in both directions. However, ductility is much lower in the transverse direction than in the longitudinal direction.

In the vacuum melted alloys, tensile and yield strengths are practically identical in both directions and the transverse ductility is not much lower than the longitudinal ductility.

Comparing the properties of the air and vacuum melted materials in Table 4 shows that, in general, the strengths are not greatly different but there is a marked increase in the ductility after vacuum melting as shown by elonga-

TABLE 4—ROOM TEMPERATURE PROPERTIES

Alloy	Heat Treatment	Melting Method	Testing Direction	Ten Str, 1000 psi	Yld Str (0.2% offset), 1000 psi	Elong (2 in.), %	Red. of Area, %	Impact Str (Charpy V), ft-lb
4340	Norm 1600 F, 2 hr at 1500 F, oq; temp 2 hr at 35 F	Air	Long.	290	222	10	35	—
			Trans.	288	221	5	17	—
		Vac.	Long.	285	215	12	41	—
			Trans.	287	222	10	40	—
6150	To Rockwell C45-48	Air	Long.	230	226	13	45	10
			Trans.	230	226	7	15	7
		Vac.	Long.	230	215	12	50	20
			Trans.	230	215	10	35	16
UHS260	1 hr at 1700 F, oq; temp 2 hr at 550 F	Air	Long.	280	240	12	39	—
			Trans.	281	246	5	10	—
		Vac.	Long.	270	233	12	44	—
			Trans.	270	236	11	38	—
VascoJet 1000	To 280,000-300,000 ten str	Air	Long.	288	235	8	28	18
		Vac.	Long.	289	234	11	51	24
A286	—	Air	Long.	290	248	3	5	—
		Vac.	Long.	282	251	8	24	—
Discaloy	—	Air	Long.	135	90	17	22	—
		Vac.	Long.	140	85	25	30	—
W-545	—	Air	Long.	168	128	13	17	—
		Vac.	Long.	173	132	17	22	—

tion, reduction of area and impact tests.

▸ Fig 1 shows the effect of vacuum induction melting on the transverse ductility of AISI 4340 at several strength levels. There is a significant improvement in ductility at all strength levels. Although data are not shown, there is less improvement in longitudinal ductility.

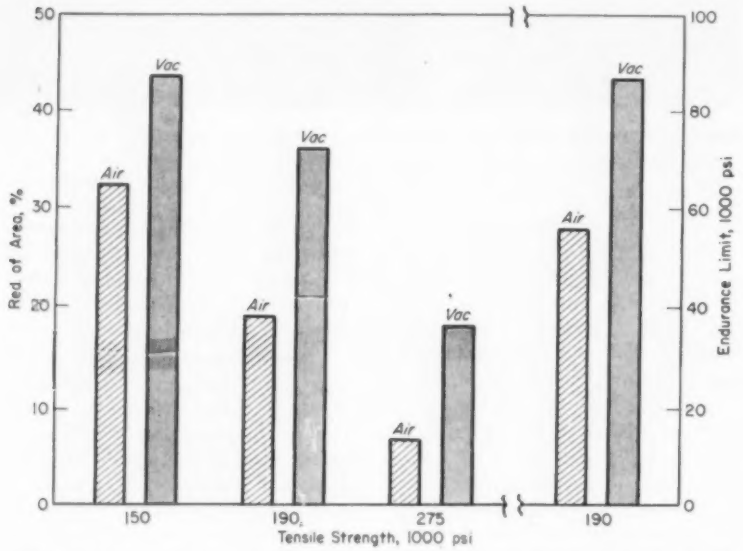


Fig 1—*Transverse properties of air melted and vacuum arc melted AISI 4340.* (Dyrkacz, Defries and Pitler)

▸ Comparison of the endurance limit of AISI 4340 after air and vacuum melting shows an increase from 92,000 psi to 107,000 psi in the longitudinal direction and 56,000 psi to 87,000 psi in the transverse direction as the result of vacuum arc melting. It is particularly noteworthy that the transverse endurance limit of the vacuum melted material is almost as good as the longitudinal endurance limit of the air melted material. Since these results were obtained on the same heat of steel, the improvement can be attributed directly to the effects of vacuum melting.

▸ Segregation in the center of large billets is a problem in such applications as gas turbine wheels where center ductility is important. In turbine wheel materials such as A-286, center ductility decreases with increase in segregation, and generally the segregation becomes progressively worse as the ingot size increases. The segregation problem is minimized by vacuum arc melting because of the rapid cooling and solidification rates. Fig 2, which compares the ductility of transverse specimens taken from vacuum and air melted billets ranging from 7 to 10½ in. square, shows the improvement resulting from vacuum melting.

▸ High chromium alloys, such as types 430 and 446 ferritic stainless steels, normally exhibit brittle fracture at room temperature. Vacuum melting techniques have

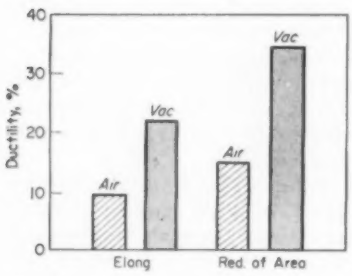


Fig 2—*Transverse ductility in center of A-286 billets after air and vacuum melting.* (Dyrkacz, Defries and Pitler)

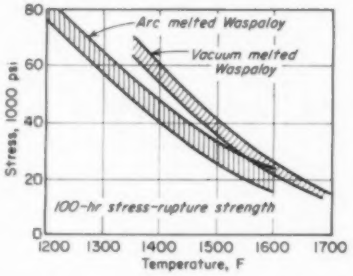


Fig 3—*Stress-rupture properties of air melted and vacuum melted Waspaloy.* (Chesnut)

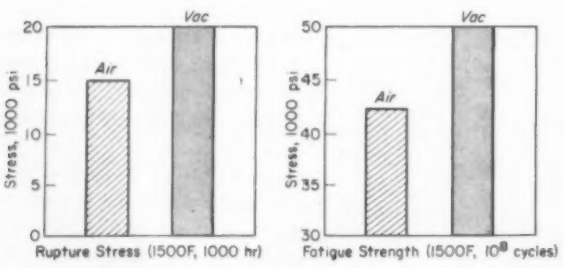


Fig 4—*Rupture and fatigue strength of M-252 after air and vacuum melting.* (Jones)

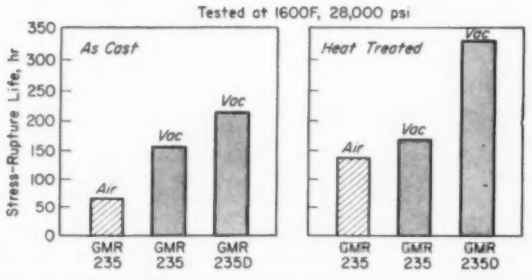


Fig 5—*Stress-rupture properties of air and vacuum melted GMR-235, and effect of modification in composition (GMR-235D).* (Metal Progress, May '58)

permitted production of these alloys with substantially lower transition temperatures and consequently greatly improved room temperature impact strength. In type 430, the transformation temperature was lowered from 212 F to —40 F by changing from air to vacuum induction melting; as a result, the room temperature impact strength increased from 8 ft-lb to 220 ft-lb. Similar improvements were found in tests on type 446 stainless steel.

. . . at elevated temperatures

Waspaloy was one of the earliest materials to be produced commercially by vacuum melting, and the improvement in stress-rupture properties has been discussed frequently. Briefly, the original specification for air melted Waspaloy called for a minimum rupture life of 23 hr under a load of 27,000 psi at 1500 F; no ductility requirement was specified. Recently, vacuum melted Waspaloy has been produced which withstands 75 hr under 40,000 psi load at 1500 F and in addition has a minimum elongation of 10%.

This great improvement in stress-rupture properties cannot be attributed solely to vacuum melting. It results from a combination of vacuum melting and a modification of the composition.

In nickel alloys such as Waspaloy, air melting results in the formation of significant quantities of titanium oxide and nitride. Vacuum melting not only produces a cleaner material, free from inclusions of this type, but also releases the titanium for its proper function in alloying with the base metal; the strengthening effect is reflected in increased high temperature strength.

In alloys of this type, vacuum melting also permits lowering the content of the normal deoxidizers, manganese and silicon, because carbon functions with greater effect at low than at normal pressures. Elimination of manganese and silicon results in improved high temperature properties.

Finally, the discovery that small additions of boron and zirconium had a beneficial effect on high temperature properties led to further modifications of the alloy. Thus, the original Waspaloy is not the same alloy as that being produced currently, and direct comparison of properties of the older with the new material is not valid. Fig 3, showing stress-rupture properties of air melted and vacuum melted Waspaloy, should be considered with this restriction in mind.

TABLE 5—STRESS-RUPTURE PROPERTIES

Alloy	Melting Method	Temp, F	Rupture Properties		
			Time, hr	Stress, 1000 psi	Elong, %
Discaloy	Air	1200	75	60	3
	Vac	1200	210	60	12
W-545	Air	1200	49	80	4.6
		1300	31	65	3.8
	Vac	1200	130	80	8.0
		1300	50	65	8.3
R-235	Air	1500	100	32	3.0
		1600	100	22.5	3.5
		1700	100	6.8	—
	Vac	1500	100	38	5.5
		1600	100	24	16.0
		1700	100	13	19.5
X-40	Air	1500	300	24.2	—
	Vac	1500	300	26.9	15

▸ A comparison of the stress-rupture properties of several alloys after air and vacuum melting is shown in Table 5. Although the life, or conversely the stress, is generally higher after vacuum melting, particularly significant is the improvement in ductility.

▸ Another example of the improvement in properties resulting from vacuum melting is shown in Fig 4. In this alloy, M-252, both rupture and fatigue strength are higher in the vacuum melted than in the air melted alloy. René 41, a recently developed modification of M-252, further improves the rupture properties.

▸ Vacuum melting has a very definite advantage in permitting the use of greater percentages of such alloying elements as aluminum and titanium than can be successfully added during air melting. This ability to increase the hardener content has been employed in various nickel, cobalt and iron-base alloys in the development of a whole new series of high temperature materials. Fig 5 shows the rupture properties of GMR-235 and includes also the properties of a modified alloy, GMR-235D. It is apparent that the rupture properties have been significantly increased by the change in composition.

▸ Vacuum melting will not always improve an alloy. Reducing the gas content in a titanium-hardened nickel-base high temperature alloy may improve the ease of fabrication and the high temperature properties. Reducing the gas content by the same amount in mild steel or a columbium-stabilized austenitic stainless steel results in little improvement; in fact, the columbium-bearing stainless steel may have lower creep strength after vacuum melting because of the removal of nitrogen.

. . . of magnetic materials

Magnetic properties can also be improved by vacuum melting; the magnetic permeability of high purity iron has been increased tenfold by vacuum treatment to reduce the nitrogen content. A magnetic nickel-iron alloy containing 40% iron had a coercive force only one-fifth that of an air melted alloy of similar composition.

. . . of bearing materials

It has been known for a long time that the life of a bearing is greatly influenced by the presence or absence of inclusions and large carbide formations. In general, standard 52100 bearing steels having excessive inclusions have poor average life; steels having average inclusions have bearing lives equal to those predicted in published handbooks; exceptionally clean steels provide bearing lives up to twice the predicted life. Just why inclusions are so detrimental is not known.

Although electric furnace steel fairly free from inclusions has been produced in isolated cases, vacuum melting is the most consistent method of producing bearing steel free from inclusions. Vacuum melted 52100 ball and ring materials have shown test endurances consistently averaging twice those of similar electric furnace steel.

Workability is also improved

In addition to properties that can be measured quantitatively, there are properties that can only be indicated on a qualitative basis. Of particular significance in this discussion is workability.

Vacuum melting prevents the formation of such compounds as

Vacuum Degassing

"Vacuum degassing" in this country refers to vacuum pouring, which involves melting in conventional furnaces and teeming into an ingot mold placed in a vacuum tank. Reduction of hydrogen content and prevention of oxidation of the molten steel during teeming result in improvements in the product.

An important advantage of vacuum pouring is its applicability to large tonnages. Ingots as large as 120 in. in dia and weighing 500,000 lb can be produced at per-lb costs much lower than those of vacuum induction or vacuum arc melting.

Reduces flaking—The major application of vacuum pouring at present is the production of large forgings in which formation of flakes is a problem.

Hydrogen is generally considered responsible, at least in part, for the formation of flakes. For the successful production of large highly alloyed forgings, the hydrogen content must be minimized. Conventionally, this is accomplished by a long heat treatment that causes the hydrogen to diffuse out of the ingot. Prevention of flaking by means of extended thermal cycles becomes uneconomic as forging size increases.

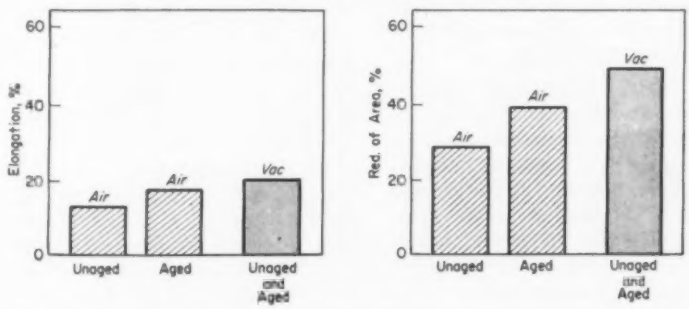
The ideal method of melting without hydrogen pickup would be use of a vacuum, but this procedure is impractical for large heats. Therefore teeming in a vacuum has been adopted by some producers, both in the United States and in Germany. Vacuum pouring in one plant reduced the hydrogen content by an average of 63%. Apparently nitrogen and carbon monoxide are also reduced although the extent of removal has not been definitely established.

The greatest improvement resulting from vacuum pouring is improvement in internal soundness and reduction of flaking and micro-crack formation. The product of the degassed ingot is much less flake-sensitive than that of the conventional ingot. The extent of improvement depends on the nature of the steel composition.

Reduces hydrogen embrittlement—Some steels are sensitive to hydrogen embrittlement. In air melted steels of this type, aging at temperatures from 212 to 500 F improves the ductility although there is little change in strength. Vacuum poured steels do not show this difference on aging. The accompanying bar chart contrasts the ductility of conventionally poured and vacuum poured nickel-vanadium-molybdenum steel; not only has the vacuum treatment eliminated the aging requirement but it has also resulted in increased ductility.

Although forging steels of the nickel - chromium - molybdenum-vanadium and chromium-molybdenum-vanadium types are not sensitive to the type of hydrogen embrittlement indicated by diminishing tensile ductility, and therefore show no improvement in properties on aging, steels of this type are considerably more ductile after vacuum pouring than after conventional pouring. The property improvement cannot be attributed to removal of hydrogen but is probably the result of increased cleanliness.

Likely to expand in use—Vacuum pouring of large ingots is economically practical now and it is likely to become more important in the future as material requirements become more rigid. In the production of large forgings for critically stressed parts, vacuum pouring will probably be used for all hydrogen-sensitive compositions and even for compositions not sensitive to hydrogen.



***Effect** of vacuum degassing on ductility of nickel-vanadium-molybdenum forgings.* (Stoll)

titanium oxide and nitride which tend to concentrate in the cast ingot grain boundaries and prevent workability entirely in some alloys or greatly reduce the yield in others. For example, Waspaloy has about 4.5% total content of aluminum and titanium. This alloy can be hot worked after either air or vacuum melting. On the other hand, Udimet 500, an alloy developed for vacuum melting and having 6% total content of aluminum and titanium, can be hot worked if it is vacuum melted but cannot be hot worked if attempts are made to produce it by air melting. Among other alloys for which this is true are thermenol and alfenol.

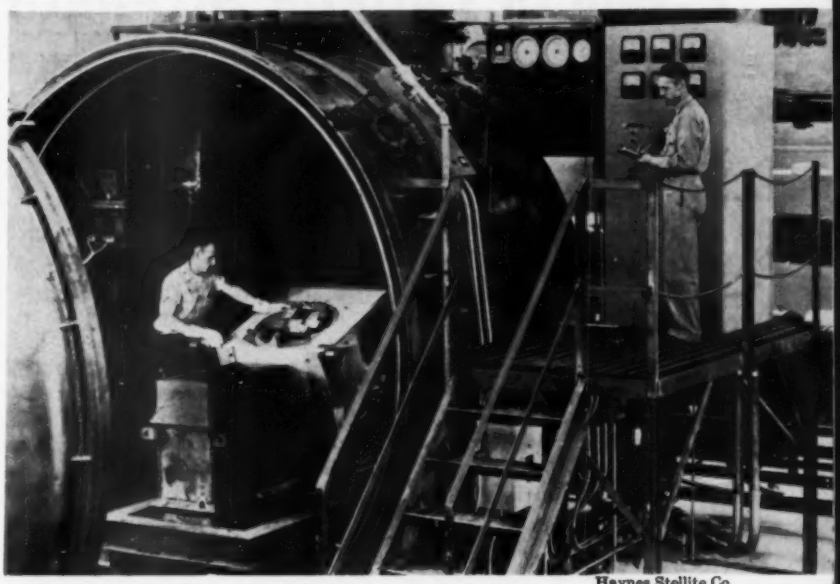
Metals Div., Kelsey-Hayes Co.

Waspaloy billet *produced by vacuum induction melting.*

Producers of Vacuum Melted Materials

Allegheny Ludlum Steel Corp.
Bethlehem Steel Corp.[a]
Cannon-Muskegon, Inc.
Carpenter Steel Co.
Crucible Steel Co. of America
Wilbur B. Driver Co.
Driver-Harris Co.
Firth-Sterling, Inc.
General Electric Co., Metallurgical Products Div.
Haynes Stellite Co.
International Nickel Co.
Metals Div., Kelsey-Hayes Co.
Latrobe Steel Co.
Mallory-Sharon Metals Corp.
Midvale-Heppenstall Co.
Timken Roller Bearing Co.
Universal-Cyclops Steel Corp.
United States Steel Corp.[a]
Vanadium-Alloys Steel Co.
Westinghouse Electric Corp.

[a] Vacuum degassing.



Haynes Stellite Co.

Vacuum induction furnace *differs from atmospheric furnaces only in the operating pressure. Temperature and working of melt are identical in both processes.*

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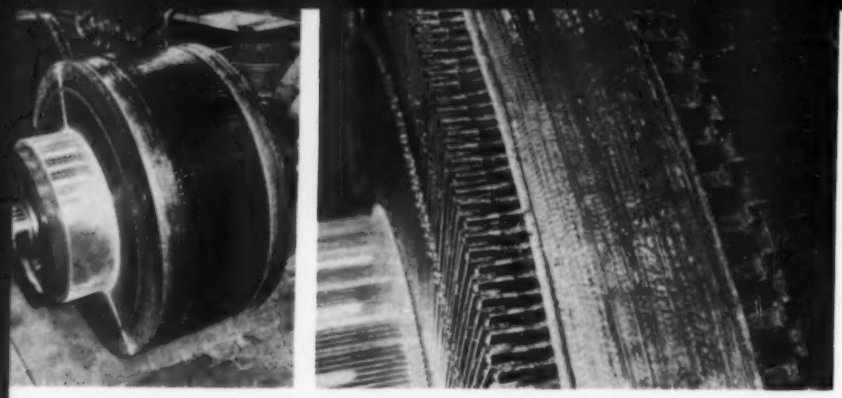


***Armature binding bands** of glass reinforced plastics are one example of the importance of accurate plastics fatigue data.*

Short-Time Test Predicts Fatigue Strength of Plastics

by L. S. Lazar, *General Engineering Laboratory, General Electric Co.*

■ The table shows the close correlation between fatigue limits obtained by accelerated fatigue tests with those obtained by conventional long-time Wöhler tests. To emphasize the correlation the last two columns compare the fatigue strength deviations with deviations normally obtained in a conventional ASTM tensile strength test.

The accelerated method used in obtaining this data requires a graph (such as the sample shown here) to be drawn through the points by the method of least squares and extended to intercept the y-ordinate at a point which the theory assumes to be the endurance limit.

Background

The need for an accelerated fatigue test for plastics was twofold: 1) fatigue data became more necessary with the increased availability of high strength plastics, and 2) the classical Wöhler method is too time-consuming.

The Wöhler method requires the application of various alternating, but constant-value, stresses until failure occurs or until an arbitrarily chosen number of cycles is reached. In addition to the costly and time-consuming nature of the tests, the method is confusing because the data are highly scattered and require the treatment of failures and nonfailures at the same stress levels.

The progressive stress method of accelerated fatigue testing of metals was developed by *E. M. Prot* in 1948. Stated simply, it requires progressively increasing the alternating stress. Various linear rates of increase are used, and the failure stress points are plotted against the square root (the 0.5 power) of the rate of increase.

Recent studies involving metals have led independent investigators to try various modifications of both test procedure and analysis technique. These studies included attempts to determine the effect of varying the initial stress applied, varying the rate of stress increase, and using predetermined exponents ranging from 0.31 to 0.71. At the present time the method appears more feasible for ferrous metals than nonferrous. However, no generally accepted conclusion has been reached. A recent paper by *N. Enomoto,* presented at the June meeting of the American Society for Testing Materials, proposed stepwise loading using only one loading rate.

In 1954 General Electric began investigating application of the Prot method to plastics. The method appeared promising when applied to comparatively simple plastics systems such as polymethyl methacrylate, polystyrene and nylon under a variety of fatigue conditions, as well as to glass cloth-reinforced laminates under axial fatigue. Analogous results were also reported by *J. M. Zarek.*

All of GE's work on plastics fatigue testing was based on a new

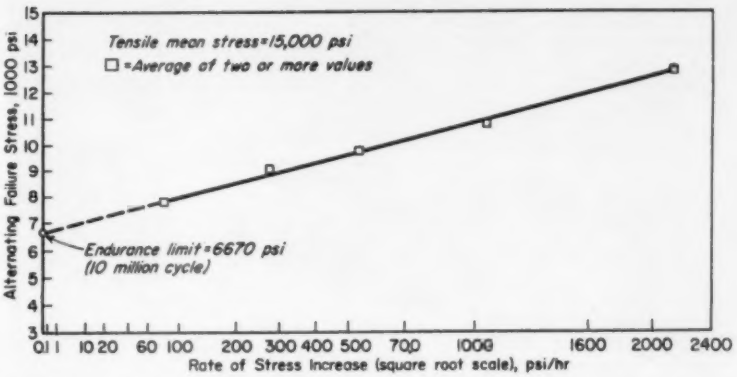
FATIGUE ENDURANCE LIMITS OF HIGH STRENGTH PLASTICS

Plastic	Reinforcement or Filler	Mean Tensile Stress, psi	Endurance Limit, psi[a]		End. Limit Deviation, %	ASTM Ten Str Deviation, %
			Accelerated	Conventional		
Epoxy[b]	181 Glass Cloth	15,000	6670	7000	4.7	6.0
Silicone	Glass Cloth	5400	1140	1100	3.7	7.4
	Glass Cloth	4900	1215[c]	1000[c]	22.5	16.0
	Glass Cloth	0	4720	4000	18.0	7.4
Phenolic[b]	181 Glass Cloth	12,200	3341	3500	4.5	6.8
	Wood Flour	2036	1855	1700	9.1	9.7
Polyester	Glass Mat	3700	2520	2500	0.8	13.4

[a]Tested at 75 F unless otherwise indicated. [b]High heat resistant. [c]Tested at 356 F.

mathematical derivation (see box), the development of which made the basis of the theory more acceptable. This mathematical derivation illustrates that the success of the method as presently applied depends upon the progressive stress failure-time data conforming to a rectangular hyperbola.

More recently this technique has been re-analyzed by H. S. Endicott and W. T. Starr to overcome the limiting assumption of the rectangular hyperbola (the re-derivation will be published by GE). As a result, it has been found that success of using progressively increasing stress to predict fatigue, creep-rupture and long-term dielectric strength depends only upon the failure point curves obeying some single, mathematically describable curve.



Typical plot *of results obtained in an accelerated test for tensile fatigue. The material is an epoxy glass-cloth laminate; the plot indicates an endurance limit of 6670 psi. The results of similar plots for other materials and conditions are given in Table 1.*

The Progressive Stress Method —How It Is Derived

The method involves applying a stress, S_o, which is below the endurance limit stress, S_e, and increasing the applied stress at a constant rate, a, until failure occurs at stress S and time t. It is assumed that fatigue takes place only when the stress equals or exceeds S_o.

If S_e were known, then progressive loading could be started at stress S_e and zero time. Making a second basic assumption—that the curve joining the failure stress-time points is a rectangular hyperbola, we get the following equations:

$$S-S_e=at;\ (S-S_o)t=K$$

But S_o is unknown and loading is begun at a lower stress, S_o. The hyperbolic curve is obtained by translating the intercept ts_o to zero time, represented thus:

$$S-S_e=a(t-ts_o);\ (S-S_o)(t-ts_o=K$$

Eliminating $t-ts_o$ from the equations yields:

$$(S-S_o)^2=Ka.$$

The same equation, written in the form: $S=S_o+(Ka)^{0.5}$, demonstrates that a plot of failure stress vs the square root of rate of load increase should yield a straight line which can be extended to intersect the stress ordinate ($a=0$) at the endurance limit, S_o.

Rate of loading

In applying the theory, strict attention must be paid to the loading rates used. Fast rates of loading result in lower failure stresses and, if only these data were available, the determined endurance limit would be too high.

This contradiction is logical because the assumption has been made that a straight-line plot is obtained only when the coordinates of failure stress and failure time describe a hyperbola asymptotic to the endurance limit. The assumed hyperbola could not be asymptotic to the y-ordinate because materials do not possess infinite strengths at the fast rates of increase. At these rates, failure occurs in the y-ordinate region of the assumed hyperbola, and the experimentally determined failure stress here is lower than that associated with the theoretical hyperbola.

In the work reported here, slower rates of increase of stress were purposely used to avoid the region of doubt.

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Paper mill storage tanks *containing hot liquors are protected with coating containing low density filler compound.*

Chemical plant equipment *protected with a medium-density-filled coating include spheres, pipe and supporting structures.*

What Are Bituminous Coatings?

Bitumens can generally be described as inert materials with thermoplastic properties. The bitumens used to produce bituminous coatings are derived from three sources: 1) asphalt produced by the distillation of petroleum, 2) naturally occurring or mined asphalts, and 3) coal tar produced by destructively distilling coal.

It is customary to classify bituminous coatings by their end-use function as well as by their generic composition. All of the coatings can be divided into two classes depending on whether or not they are heated prior to application:

Hot-applied coatings usually consist of 100% bitumens and selected fillers. Hot coatings are brought to the desired application viscosity by heating, without the need for solvents, and are widely used on pipes.

Cold-applied coatings are formulated with solvents or water to achieve proper application viscosity. A wide range of solvents is used; the final choice depends on the drying properties desired and the solvent power required to dissolve the particular bitumen being used. Various fillers are also used in cold-applied coatings to obtain specific application and end-use properties.

- *Long service life*
- *Resistance to weathering, corrosion and abrasion*
- *Good thermal and sound insulating properties*

are some of the reasons for using

Bituminous Coatings

by Stephen H. Alexander and Ray D. Cunningham,
Lion Oil Co., Div. of Monsanto Chemical Co.

These coatings can meet many end-use requirements

Bituminous coatings can be formulated from several combinations of coating blends and fillers to meet a wide range of operating requirements. The coatings that can be produced range from thin-film coatings used to protect machined parts in storage, on up to thick, tough coatings to protect buried pipe lines.

The following questions and answers indicate the end-use requirements that should be considered and how well bituminous coatings satisfy them. Although the discussion generally applies to all bituminous coatings, keep in mind that there may be individual differences between coating types. Individual differences are discussed in the later section on types of coatings and in the summary table.

1. What temperature extremes will the coating be subjected to?

Most bituminous coatings are used over a moderate temperature range no greater than that caused by weather changes. However, other coatings such as those used on chemical processing vessels require a much wider temperature range. In general, bituminous coatings provide good performance over a temperature range of −100 to 325 F.

2. Are thermal and electrical insulating properties desirable?

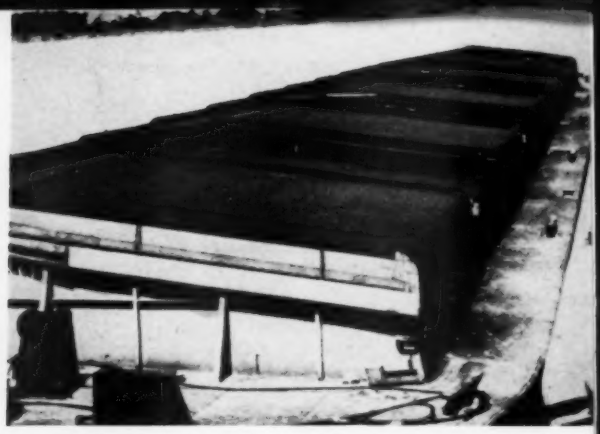
Bitumens themselves are relatively poor thermal insulators. However, by using low density fillers, coatings with good insulation properties can be formulated. These coatings perform the double function of providing both corrosion protection and thermal insulation. The low density insulating fillers are completely surrounded by the bitumen and are thereby permanently protected from moisture. Thus, they are not subject to the loss in efficiency experienced by conventional insulations which can be damaged by the failure of their protective vapor barriers.

TABLE 1—PROPERTIES OF COLD-APPLIED COATINGS

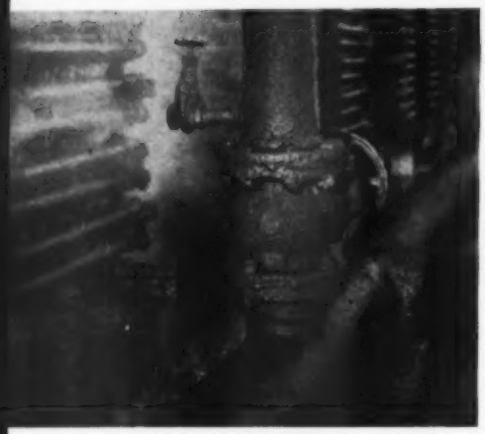
Type →	Asphalt-Base						Coal Tar-Base			
	Thin Film	Industrial Mastic (fibrous fillers)	Railroad Car Cement	Automotive Undercoating	Sound-Deadener	Insulating Coating	Thin Film	Mineral-Filled	Industrial Mastic (fibrous fillers)	Epoxy-Modified
PHYSICAL PROPERTIES										
Flash Point (Pensky-Martens), F	105	105	105	105	80	105	100	100	100	100
Ther Cond, Btu/hr/sq ft/°F/in.	—	1.7	—	—	—	0.6	—	—	—	—
Service Temp Range, F	−60 to 250	−60 to 325	−60 to 325	−60 to 325	−40 to 325	−40 to 275	250 max	160 max	250 max	−30 to 400
Sound Deadening Ability (at 0.5 lb/sq ft), db decay										
At 0 F	—	—	—	13.6	10.4	—	—	—	—	—
At 50 F	—	—	—	8.2	15.0	—	—	—	—	—
At 70 F	—	—	—	5.9	12.2	—	—	—	—	—
At 110 F	—	—	—	3.8	6.8	—	—	—	—	—
MECHANICAL PROPERTIES										
Abrasion Resistance	—	Good	—	Good	—	Good	—	—	—	—
Adhesion at Low Temp	Good	Good	Good	Good	Good	Good	—	—	—	Good
CHEMICAL AND CORROSION RESISTANCE										
Dilute Hydrochloric, Sulfuric and Phosphoric Acids	Good	Good	Good	Good	—	Good	—	Good	—	Good
Nitric Acid	Poor	Poor	Poor	Poor	—	Poor	—	Poor	—	—
Sodium Hydroxide	Good	Good	Good	Good	—	Good	—	Good	—	Good
Ammonium Nitrate or Sulfate Sol'ns	Good	Good	Good	Good	—	Good	—	Good	—	Good
Oils, Greases, Petroleum Solvents	Poor	Poor	Poor	Poor	—	Poor	—	Good	—	Good
Outdoor Weathering	Exc	Exc	Exc	Exc	—	Exc	Poor	Fair	Fair	Fair
Salt Spray, min hr	360	500	—	500	—	—	—	—	—	—
Water Vapor Permeability (wet cup), grains/sq ft/hr/in. Hg/in.	—	0.0018	—	—	—	0.007	—	—	—	—
APPLICATION										
Solids Content (by wt), %	60	70	64	65	80	61	65	70	72	70
Mineral Filler (by wt), %	Nil	22	18	28	60	—	Nil	25	25	20
Fibrous Filler Present?	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
Application Methods*	B, D, S	B, S, T	B, S	B, S, T	S, T	S, T	B, D, S	B, S	B, S, T	B, S
Usual Film Thickness, mils	3	63	6.5	63	27	250	3	15	72	15

*B = brush, D = dip, S = spray, T = trowel.

***Bus interior** is sprayed with special sound deadening coating to lower noise level.*



***Barge structure** is coated with medium-density-filled compound for protection against weathering.*



***Steel mill condenser,** pipes and valves are given a bituminous coating to prevent corrosion.*

Bitumens are naturally good electrical insulators. This is an important consideration when electrical devices are used to give complementary cathodic protection to the coated structure.

3. Will weathering properties be an important consideration?

By careful selection of composition and processing methods, bituminous coatings can be formulated to resist weather for many years. Many coatings have been in use for over 10 years and are still in good condition. In general, asphalt-base bituminous coatings weather better than coal tar-base coatings. Also, there is a wide difference in the performance of asphalt coatings derived from different petroleum crudes. Thus, selection of the best coating for outdoor applications should be made by consulting with the coating formulator.

4. What corrosive solids, solutions and vapors will be encountered?

In general, the resistance of bituminous coatings to corrosive media is equal to that of the best organic coatings. Bituminous coatings have good resistance to dilute hydrochloric, sulfuric and phosphoric acids as well as to sodium hydroxide. They also have good resistance to solutions of ammonium nitrate and ammonium sulfate. However, they have poor resistance to dilute nitric acid, and most coatings are not resistant to oils, greases and petroleum solvents.

5. Will the coating be subject to mechanical and/or thermal shock?

Bituminous coatings generally have good adhesion when subjected to mechanical shock. However, where severe mechanical shock is expected the coatings should first be field tested or tested in the laboratory under simulated service conditions. A common laboratory test used to evaluate automotive coatings consists of a slamming device in which a coated panel is mounted on a hinged frame and allowed to swing freely against a stop. Properly formulated coatings can withstand this type of abuse even when the test is conducted at low temperatures representing the most severe operating conditions.

Adhesion after impact can also be determined by using a free falling weight on a coated panel. In a standard test used on hot-applied pipe coatings, a 2-in. dia steel ball is dropped from a height of 1 ft on the coated specimen which is maintained at 32 F. A properly formulated coating will withstand this test without cracking or shattering.

Resistance to thermal shock is an important consideration in coatings used on some types of processing equipment. Laboratory tests in which a coated panel is transferred back and forth between hot and cold chambers can be used to predict field behavior. Bituminous coatings are available which will withstand thermal shock over a temperature range of –60 to 140 F.

6. Will abrasive materials be encountered?

A good example of the high abrasion resistance of bituminous coatings is their use as automotive undercoatings. These coatings successfully withstand the continuous abrading action of gravel and debris thrown up by the wheels of the vehicle. They also meet Federal Specification TT-C-520 which requires that coatings withstand 20 passes under a sandblast nozzle operated at a pressure of 90 to 100 psi. Special coatings on the inside of vessels are also capable of handling corrosive or abrasive solids.

7. Will decorative colors be needed?

It is not practical to produce colors in bituminous coatings by

***Pipe** coatings have high resistance to corrosion and mechanical damage. Coatings are applied by special machine which travels along pipe.*

***Tank car** is coated with medium-density-filled coating to resist corrosion by liquid chemicals.*

pigmentation. However, if color is important certain colored paints can be used as topcoats. Granules can also be blown into the coating before it is completely cured to produce a wide range of decorative effects.

8. How important is cost?

So many factors affect the as-applied cost of bituminous coatings that it is difficult to give any specific cost figures. Depending on the application, a bituminous coating can either be cheaper or more expensive than a competitive coating (such as a vinyl). In addition to the basic cost of the coating material, the engineer has to take into account such variables as: volume of material to be used, geographical freight rates, degree of surface preparation required, application equipment available, labor costs and many factors. Thus for a given application and set of properties, the cost of bituminous coatings in comparison with other coating systems can only be determined by consulting with coating formulators.

Six basic types of coatings are available

Thin-film coatings

For classification purposes, thin-film coatings are defined arbitrarily for the most part as solvent cutback coatings with a thickness of less than 6 mils. They are comparatively low in cost and can be used to give good corrosion protection where color is not too important. Except for aluminum paints using bituminous bases, the coatings have a natural black color.

Thin-film asphalt coatings are widely used to protect machined parts in storage. Such coatings can be easily removed with kerosene or similar solvents when the part is ready for use. Coatings based on coal tar cannot be used for temporary protective applications because they are difficult to remove with solvents. However, this resistance makes coal tar-base coatings useful for protecting the bottoms of crude oil tanks and other products requiring resistance to solvent petroleum fractions.

Industrial mastic coatings

The rugged properties of heavy-bodied industrial bituminous coattings are obtained by incorporating mineral fillers. Various fillers can be used to produce coatings as thick as 250 mils that will not slump or flow on vertical surfaces. However, normal thicknesses for industrial coatings range from 6 to 120 mils.

As shown in the tables, industrial bituminous coatings can be based on either coal tar or asphalt. Choice of the coating and thickness to use depends on the environment and the practical application methods available. The extreme toughness of coal tar coatings modified with epoxy resins can be especially valuable in special applications. On the other hand, the better weatherability, plasticity and cold flow properties of asphalt-base coatings compared to coal tar-base coatings should be considered, especially where sunlight exposure is involved.

Industrial mastic coatings are used extensively to protect tanks and structural steel. In such applications they provide good protection from such corrosive media as acids, alkalis, salt solutions, ammonia, sulfur dioxide and hydrogen sulfide gases.

Industrial mastic coatings are widely used in railroad applications. They are useful on tank cars carrying corrosive liquids, particularly in protecting saddle areas where spillage is likely to occur. They are also useful in protecting the interior and exterior of hopper cars against the corrosive action and abrasive wear of dry chemicals.

So-called railroad car cements can be used to seal sills and joints in boxcars. They provide an excellent roofing system for car roofs when covered with a granule-bearing bituminous topcoat.

Automotive underbody coatings

These are mastic-type coatings containing fibrous and other fillers. They are principally designed to prevent corrosion, reduce noise and seal joints on the undersides of floor panels, fenders, gasoline tanks and frames. They are particularly effective in reducing corrosion in fenders which are continually subject to corrosive road

debris and de-icing salts. The sound deadening properties of the coatings appreciably reduce noise levels inside the automobile and provide a more pleasant and less fatiguing ride. The sealing and bridging action of the coatings is especially effective in reducing drafts and dust infiltration.

Sound-deadening coatings

High efficiency sound-deadening coatings are formulated from selected resinous bitumens and high density fillers. They have better sound insulating properties than automotive underbody coatings and are widely used on the wall, roof and door panels of automobiles and buses where sound-deadening properties, rather than resistance to abrasion and corrosion, are needed. The coatings are also popular for railroad passenger cars, house trailers, stamped bath tubs, kitchen sinks, air conditioning cabinets and ventilating ducts.

Thermal insulation coatings

Low density fillers can be used in bituminous mastics to produce coatings with relatively good insulating properties, a K value of 0.6 Btu/hr/sq ft/°F/in. being typical. When used on vessels these coatings perform the dual function of reducing heat transfer and preventing corrosion. They are usually applied in thicknesses (about 250 to 375 mils) somewhat greater than conventional mastics to obtain the desired insulating value. Because of their thickness and resiliency the coatings have excellent resistance to mechanical damage.

Pipe coatings

In general, the industrial coatings described above can provide excellent protection on pipe located above ground. However, for underground pipe—both unprotected and cathodically protected—specially formulated asphalt and coal tar-base coatings are required. These coatings (see Table 2) are usually applied hot, and the pipe is installed underground immediately after the coating has cooled. The effectiveness of the coatings can be increased by wrapping them with rag, asbestos or glass felt. Embedded wraps can also be produced by tightening a glass fabric wrap around the coating while it is still hot.

Pipe coatings are especially tough and can withstand the stresses caused by soil shifts. They also have good cold flow properties and resist the high localized pressures (up to 100 psi) caused by rocks, dirt clods and other sharp objects.

Because of their comparatively high electrical resistance, bituminous pipe coatings can reduce the cost of cathodic protection. Cathodic protection is accomplished by maintaining a negative electrical potential on the pipe. The cost of maintaining this potential is determined by the current drain, which in turn depends on the electrical resistance of the coating.

TABLE 2—PROPERTIES OF POPULAR HOT-APPLIED PIPE COATINGS

Type →	Asphalt-Base		Coal Tar-Base	
	Culvert Pipe Coating	Buried Pipe Coating	Buried Pipe Coating, Narrow Range[b]	Buried Pipe Coating, Wide Range[c]
Mineral Filler Content (by wt), %	None	19	22	23
Flash Point	575	600	465	—
Penetration (ASTM D5-52), mils				
At 32 F	130	20	—	—
At 77 F	189	32	4	39
At 115 F	303	59	16	83
Softening Point (ASTM D36), F	200	240	195	225
Max Temp Without Sagging, F[a]	—	160	120	160
Min Temp Without Cracking, F[a]	—	−20	30	−20
Resistivity, ohm-cm	—	1.8×10^{16}	5.5×10^{12}	—
Film Thickness per Coat, mils	30	95	95	95
Coverage, sq ft/ton/mil	374,000	321,000	268,000	263,000

[a]Asphalt Inst. procedure. [b]30 to 120 F. [c]−20 to 160 F.

How bituminous coatings are applied

Bituminous coatings can be applied without heating by dipping, brushing, spraying or troweling.

Dipping is usually used to coat small parts. As a rule, coating viscosity is adjusted to produce a thickness of 1 to 6 mils.

Brushing is used on areas that cannot be reached by spraying and on jobs that do not warrant setting up spray equipment. Coating thicknesses can range from 1 to 65 mils.

Spraying is the most popular method for applying cold coatings. The thickness required in one application determines the consistency of the formulation, and thicknesses of 1 to 250 mils are obtainable by spraying. Conventional paint spray equipment can be used for coatings up to 6 mils thick. Heavier coatings require the use of mastic spray guns fed from pressure pots or heavy duty pumps. Heated vessels and feed lines can also be used to decrease viscosity and permit faster application and the buildup of thicker films in one application.

Troweling is usually used in inaccessible areas and/or where it is necessary to produce a very heavy coating in one application. Trowel coats are usually applied in thicknesses above 250 mils.

Bituminous coatings can also be applied hot without the need for any solvent diluents. Such coatings are widely used on piping in thicknesses of about 95 mils. The formulation is heated to 350 to 550 F and then pumped into a special apparatus which surrounds and travels along the pipe.

Initial screening *of elastomers for parts such as this planishing roll can be done with standard test results. However, you must understand the terms and what they tell you about the elastomer.*

How to Interpret

Mechanical Properties of Elastomers

■ Elastomers (including both rubber and rubber-like materials) behave differently from other engineering materials. As a result, terms such as hardness, tensile strength and modulus, used to define mechanical properties of other engineering materials, have different meanings when applied to elastomers.

The purpose of this article is 1) to familiarize the engineer with these terms as they apply to elastomers, and 2) show how standard test results for these properties should be interpreted. The discussions also indicate how useful each property is in design. Since some knowledge of the test is helpful in understanding the limitations of property data, the table on p 108 gives a brief summary of some of the standard tests used.

Hardness

Hardness is one of the most widely used methods for classifying elastomers. It is a measure of relative resistance of the surface to indentation by an indentor of specified dimensions under a specified load. Numerical hardness values represent either depth of penetration, or convenient arbitrary units derived from depth of penetration.

Two major considerations must be kept in mind to properly interpret hardness values:

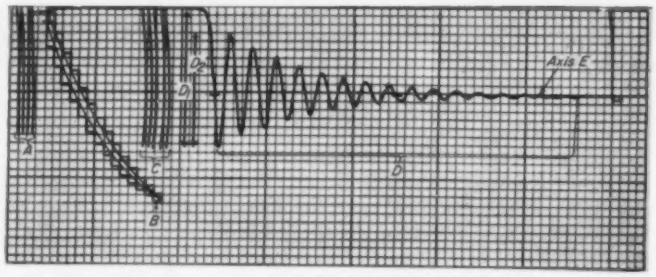
1. Hardness is an approximate measure, never a precise one. Rarely should hardness values be specified closer than ±5 durometer points. It is common to find 5, and in many cases even 10, points difference in readings made by various people using different durometers on the same piece of rubber. Even when the ASTM Hardness Tester is used as a referee method to settle disputes, accepted tolerances range from ±7 points for hard compounds to ±20 points for soft ones.

2. Surface indentation rarely bears any relation to the ability of an elastomeric product to function properly. In rare cases surface indentation has some direct significance, e.g., in gaskets to be used between two rough flanges (indentation by the point of the test instrument is somewhat similar to the indentation made by protrusions on the sealing surfaces.)

The most common—and dangerous—misconception of hardness is that it is an accurate measure of stiffness, i.e., load-carrying capacity. Hardness measurements

Adapted from *The Language of Rubber*, E. I. du Pont de Nemours & Co., Inc., '57.

How to Use the Oscillogram



Typical oscillogram *from ASTM D945 oscillograph.*

Both static and dynamic moduli of elasticity and resilience can be determined from oscillograms such as the one above. The vertical, near-parallel lines A and C are caused by conditioning of specimen.

Static modulus of elasticity is determined from the static load-deflection curves (B). The upper curve is the loading curve, and is developed by drawing a smooth curve through steps produced by applying increasing increments of load to the specimen. For these curves, the vertical axis represents strain (each square representing a strain increment of 2%); the horizontal axis represents stress (each square a stress increment of 20 psi). The chronograph drum is rotated by hand one square to the left after each weight is added.

The lower curve is developed by drawing a smooth curve through steps produced by unloading the specimen one weight at a time and rotating the drum to the right. Static elastic modulus is determined by 1) drawing a tangent to the point on the curve corresponding to stress or strain contemplated for the part in service, and 2) determining the slope of the tangent by counting squares.

Dynamic modulus of elasticity is calculated from the dampened sinusoidal curve (D). Specimen is loaded sufficiently to cause a 20% deflection. The chronograph drum is motor-driven at a surface speed of 1 in. (10 small squares) per sec. The specimen is forced to a zero-load position and released. The specimen acts as a compression spring under conditions of free vibration, producing magnified oscillations recorded on the drum. Frequency of vibration, in cps, is found by measuring (in inches along the axis E) the horizontal distance traversed by some convenient number of cycles. Effective dynamic modulus, K_e in psi, can be calculated: $K_e = 210\ If^2$, where I is the moment of inertia of the sample-loading apparatus (beam and weights), and f is frequency of vibration.

Resilience can be determined from the same oscillograph. The dampened sinusoidal curve (D) is used to determine resilience (in %) which is defined as $D_2/D_1 \times 100$.

derive from gross deformations of mations; stiffness measurements the entire mass. Consequently hardness is not a reliable measure derive from small surface deforof stiffness.

Tensile strength, elongation

The terms "tensile strength" and "elongation" when applied to elastomers mean much the same as they do when applied to other engineering materials. Tensile *stress*, more commonly called "modulus" (not to be confused with modulus of elasticity), is the stress in pounds per square inch of original cross section required to produce a certain elongation (term is used only when strains are much greater than 15%; see section on modulus of elasticity). For example, if a tensile stress of 1000 psi produces an elongation of 650%, the compound is said to have a 650% modulus of 1000 psi.

Tensile strength and elongation values for elastomers have little design significance, i.e., they bear little relation to an elastomer's ability to perform its function. Rubber products are seldom loaded in tension, and never to a degree even approaching their ultimate strength or elongation. Rubber products such as belts, hose, o-rings and mountings are rarely if ever stressed above about 100 psi, even though their ultimate tensile strength may be 1500 or 3000 psi.

Often tensile strength and elongation are used as an index to general quality of an elastomer. Such misuse can often increase the cost of your part unnecessarily. At the extremes of the tensile strength range, values may be somewhat indicative of overall quality, i.e., tensile strengths below 1000 psi usually indicate that most other mechanical properties are rather poor; tensile strengths of over 3000 psi usually indicate that most mechanical properties are good. But in the most common range of 1500 to 3000 psi, correlation is at best haphazard between tensile strength and such properties as resilience, abrasion resistance, compression set and flex life.

Tensile strength and elongation values are primarily used for compound development, manufacturing control and for determining an elastomer's resistance to deterioration by such media as oil, heat, chemicals or weathering.

Permanent set

Permanent set is the amount of residual displacement in an elastomeric part after a distorting load (tensile, compressive or shear) has been removed. Compression set, determined after compressive loading, is probably the most commonly reported type of permanent set value.

Permanent set values are useful during initial evaluation in eliminating compounds that may fall in the distinctly high permanent set range. In the lower range, dif-

ferences in values cannot be used to predict serviceability of a part. Although temperature and distortion conditions used in the test may be similar to expected service conditions, the short testing time does not approach the longer service life expected of the part.

Unfortunately, permanent set characteristics are often erroneously taken as being related to other physical properties. For example, it is often thought that low compression set is always accompanied by high resilience and low creep. Though correlations of this type may be evident when considering extreme set values, there are so many exceptions that acceptance of the general statement does more harm than good.

Stress relation, creep

Stress relaxation is the loss in stress when an elastomer is held at a constant strain over a period of time. Creep, or strain relaxation, is the gradual increase in deformation with time of an elastomer under constant load.

In many cases where compression set values are used to evaluate a compound, stress relaxation is actually the more significant property, e.g., the ability of a gasket to maintain a seal. Consequently, a variety of stress relaxation tests are now being studied by ASTM.

Creep data would be a valuable design tool, particularly in designing such parts as engine mountings, since creep influences the space relationships between various equipment parts. Yet, creep is difficult to predict without resorting to simulated service tests. Creep is affected by several factors, including strain, temperature, and changes in strain and temperature produced by vibration.

Although relative effects of variables on creep have not been fully determined as yet, long-term studies have established some general correlations: 1) the higher the initial strain, the higher the creep, 2) the higher the temperature, the higher the creep, 3) creep is greater under tensile strain than under equal shear strain, 4) creep is greater under shear strain than under equal compressive strain, and 5) creep is greater under dynamic loading than under static loading.

Modulus of elasticity

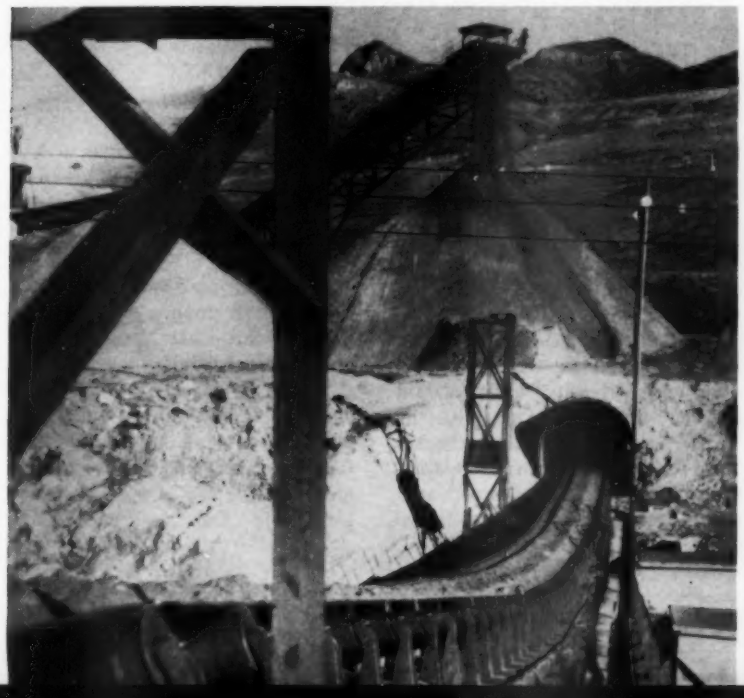
Modulus of elasticity, in an elastomer as in steel, is the ratio of stress to strain. But in elastomers measurements are made in compression (or shear), rather than tension, and are only valid for strains up to about 15%. (Modulus of elasticity should not be confused with the loose term "modulus" which is used in the rubber industry to describe tensile stress; see previous section on tensile strength and elongation.) Within this low strain region, an elastomer's stress-strain curve is almost straight. Design calculations which assume stress proportional to strain may be made with tolerable error. Thus modulus of elasticity values for elastomers, unlike values for most other mechanical properties, can be used directly for design.

Because elastomers have the peculiar property of becoming stiffer when vibrated, they have two elastic moduli, static and dynamic. In highly resilient compounds dynamic modulus is only slightly greater than static; in compounds of low resilience (high hysteresis) dynamic modulus may be as much as twice the static value.

The direct utility of modulus of elasticity values stems from four features of the tests, which distinguish them sharply from other standard tests for elastomers: 1) measurements are made in compression or shear, which is the way an elastomer is almost invariably stressed in service, 2) measurements are made in the low strain range, where elastomers are usually used in service, 3) data are given in common engineering units, rather than arbitrary units, and 4) specimens are conditioned by flexing, which makes measurements both more reproducible and more indicative of the way elastomers perform in service.

Shape factor—Compression-deflection (stress-strain) characteristics of a rubber part are critically affected by the shape of the part. (Shape has only a minor effect when the part is loaded in shear or tension.) Shape is critical because when compressed a rubber part does not lose volume; it changes shape by bulging along the sides. Thus, the amount of deformation produced by a compressive stress depends on the

Simulated service tests *must be carried out before final selection of a rubber for critical applications such as this 850-fpm gravel conveyor belt.*



area of the part free to bulge. Increasing this area makes bulging easier and permits greater vertical displacement under a given stress.

The relationship between shape and compression-deflection characteristics is too complex to be covered in detail here. However, it can be briefly summarized.

For parts having parallel loading faces and sides normal to the loading faces, the influence of shape can be expressed numerically as the "shape factor." This is defined as the ratio of the area of one loaded surface to the area of all the unloaded surfaces free to bulge. Parts having the same shape factor and hardness, regardless of their actual size and shape, require about the same compressive stress to produce a given compressive strain. Unfortunately there is no consistent relationship between shape factor and compressive modulus.

As a result of extensive study of the effect of shape on compression-deflection properties, E. G. Kimmich of Goodyear Tire & Rubber Co. has produced a series of empirical curves relating the four variables of stress, strain, hardness and shape factor. These curves have been published by the ASTM *(Kimmich)* and can be used to determine quantitatively for a given part how shape factor affects compression-deflection characteristics.

Resilience, heat build-up

Resilience of rubber is the ratio (usually expressed in %) of 1) energy given up on recovery from deformation to 2) the energy required to produce the deformation. Hysteresis is the per cent energy loss per cycle of deformation, or 100% minus the resilience percentage. Hysteresis is the result of internal friction and is manifested by the conversion of mechanical energy into heat which produces a temperature rise known as heat build-up.

There are four types of tests for determining resilience. Each has limitations, primarily based on lack of correlation between test and service conditions. Limitations are mentioned in the table on p 108.

Several factors involving the interpretation of resilience and and heat build-up values should be mentioned:

1. Resilience is intimately related in a complex way to stiffness, permanent set, creep and other properties. Thus, resilience data should never be related to service performance without considering the other characteristics of the composition.

2. There is an erroneous tendency to assume that compositions having low resilience (high hysteresis) are unsatisfactory for almost any use. In some cases, hysteresis and resilience have

Mechanical Property	Standard Test	Description[a]
Hardness	Durometers[b]	Indentor point projecting from flat bottom of case, spring-held in zero position; when pressed against sample, indentor pushed back into case against spring which translates indentation res to pointer on dial. Values given in points *Note:* Calibrated arbitrarily from 0 (soft) to 100 (hard). Allow tolerance of at least ±5 pt
	ASTM D314, table-top instruments[c]	Operated similar to durometers, but indentors loaded under dead weight and dial readings are direct measurement of penetration. Values given in points *Note:* More reproducible than durometer values; each machine produces diff numerical values; the harder the sample, the lower the value
Tensile Strength, Elongation	ASTM D412	Dumbbell-shaped specimens, die-cut from flat sheet, bench-marked for elong measurement; test machine operated at 20 ipm; elong measurements taken during tensile test *Note:* "Modulus" is tensile stress measured at some particular elong
Permanent Set in Tension	ASTM D412	Std ten str specimen stretched to specified elong (usually 75% of ultimate), held for 10 min, then permitted to recover for 10 min. Permanent set given as incr in length between bench marks (in % of orig dist between them)
Compression Set	ASTM D395, Method A	Constant load: Std specimen compr between parallel steel plates under stress of 400 psi; test assembly then conditioned for selected time and temp (e.g., 22 hr at 158 F); specimens removed and allowed to recover at rm temp for 30 min. Diff between orig thk of specimen and thk after test is given as % of orig thk *Note:* Compr set used more commonly than permanent set in tension
	ASTM D395, Method B	Constant deflection: Specimen compr to specified % of orig thk, dependent on hardness of sample; assembly conditioned for selected time and temp and allowed to recover for 30 min. Diff between orig thk and thk after test given as % of the defl used
Stress Relaxation	No standard	Many labs have dev relaxation cells, using specimens and procedures parallel to D395, Method B, except that stress, rather than strain, is measured before and after conditioning period
Modulus of Elasticity	ASTM D575	Method A measures load required to cause spec defl; Method B measures defl caused by spec load; reported in engrng units *Note:* In elastomers stress is prop. to strain only in low strain region (up to 15 or 20%)
	ASTM D797	Determines load-defl char. in flex, using simple beam test. Results reported as Young's Modulus in psi
	ASTM D945	Mech oscillograph dev static stress-strain curve and effective dynamic mod of elasticity; operates in low strain range; may be used in either compr or shear; operation descr more closely in box, p 106 *Note:* Provides complete moduli curves for design

FOR ELASTOMERS

Mechanical Property	Standard Test	Description[a]
Resilience	Low speed stress-strain loop	Obtained by loading and unloading specimen in tension, compr or shear, using low strain rate and large def; area under loading curve prop. to work input; area under unloading curve prop. to energy returned by spec on retracting *Note:* Not often used, since uses for rubber parts involve vibratory stresses of high freq and low ampl
	ASTM D1054 (impact resistance)	Free-falling pendulum hammer dropped against spec. Resilience is reported as height of rebound, in % of height of drop *Note:* Not equiv to vibration test, since no cyclic interchange of potential and kinetic energy occurs
	ASTM D945 (free vibration)	Uses mech oscillograph (D945) mentioned above; resilience measurements made at same time as static and dynamic moduli determinations *Note:* Popular method because of high speed def; freq may not be same as in actual svc
	ASTM D623 (forced vibration)	Method describes three flexometers: Goodrich, Firestone and St. Joe; first two vibrate spec at const amplitude; the third at const load or const amplitude. Temp rise measured with thermocouple at base of spec *Note:* Selection of method dependent on use; type of vibration important, since heat generated per cycle 1) at const amplitude is directly prop. to stiffness of sample, 2) at constant load is inversely prop. to stiffness
Abrasion Resistance	ASTM D394	Descr both Du Pont Abrader (Method A) and National Bureau of Standards Abrader (Method B); both methods hold specimen under specified load against an abrasive mounted on a rotating disk or drum. Abrasive moves at specified speed either for a definite period of time (Method A) or until specified amount of sample is worn away (Method B). Results compared with results obtained from abrading known sample. Results expr as ratio between volumes of material abraded away from specimen and std sample *Note:* Poor correlation between test results and svc perf
Flex fatigue	—	Three std machines are Scott, De Mattia and Du Pont Flexers. With Scott Flexer, rocker arms draw sample back and forth under weighted pulleys. De Mattia Flexer bends and straightens specimen, or alternately stretches and relaxes it. Du Pont Flexer drives endless chain of test strips over and under four sets of pulleys. (ASTM D430 describes use of Scott machine to test rubber-fabric products for ply separation; D813 describes use of De Mattia machine for studying crack growth.) *Note:* Not suited for use in mtls spec requirements
Tear strength	ASTM D624	Desc proc for tensile stressing both 1) a nicked spec for res to tear propagation, and 2) unnicked spec for res to tear initiation. Results expr in lb/in. width *Note:* Useful only for lab comparisons; not applicable for svc eval

[a]Description is only intended to give general idea of how test is made; for details see *ASTM Standards on Rubber Products* (American Society for Testing Materials).
[b]Sold under proprietary names, such as Shore A, Rex and Wallace.
[c]Includes ASTM Hardness Tester, Pusey & Jones Plastometer, Firestone Penetrometer, and the Admiralty and the Wallace Hardness Testers.

little or no bearing upon performance of an elastomeric part. In some vibration damping uses, for example, a low resilience may be desirable to limit the maximum vibrational amplitude developed in service.

3. For vibration damping uses, resilience requirements are determined largely by the frequency and amplitude of vibration. If frequency and amplitude are such that the hysteresis in a low resilience compound would result in excessive heat build-up, then a compound with higher resilience is indicated.

Other properties

Other mechanical properties of elastomers commonly reported are *abrasion resistance, flex fatigue* and *tear strength*. There is no correlation between the standard test methods for these properties and service performance. In fact, ASTM specifically states this fact and cautions that test results should not be used for materials specifications. The significance of the test results can only be determined by the individual laboratory for its particular problem. In evaluating any of these properties in a rubber composition for a specific application, simulated service tests should be made.

Abrasion resistance is the resistance of an elastomer to wearing away by contact with a moving abrasive surface. It is measured under specific conditions of load and speed.

A common error is to consider abrasion resistance as a single entity like modulus of elasticity. That is not the case. Abrasion resistance is a complex of properties, including resilience, stiffness, thermal stability, and resistance to cutting and tearing.

Flex resistance is the ability of an elastomer to withstand fatigue resulting from repeated distortion by bending, extension or compression. Fatigue may result in several different types of failure. Flex cracking—the formation of surface cracks as a result of repeated bending or stretching—is probably the most common. Results of standard flex resistance tests are primarily useful in research and development work, particularly when an unknown compound is being compared with one whose performance is known.

Tear resistance is the force required either 1) to propagate a nick or cut in a direction normal to the direction of applied stress, or 2) to initiate tearing in a direction normal to the direction of the stress. Tests are primarily useful for laboratory comparisons, since tear resistance is greatly affected by fibering of the elastomer under stress, stress distribution, speed of stretching, and size of specimen.

Reference

Kimmich, E. G., "Rubber in Compression," *ASTM Bulletin*, Oct '40, p 9.

These Factors Control

High Temperature Corrosion of Metals

You should evaluate them early in the design stage when metals are to be exposed to gases at high temperatures.

by C. J. Guare, *General Engineering Laboratory, General Electric Co.*

Atmosphere

Composition, Velocity, Pressure, Oxidizing, reducing or neutral?

Temperature

Degree, Duration, Amount of cycling

Corrosion products

Composition, Structure, Porosity, Thickness, Adhesion, Coefficient of expansion

Surface

Prestressed areas, Impurities, Local alloy depletion, Surface preparation

Coating

Composition, Reactivity, Thickness, Porosity, Adhesion, Melting point, Coefficient of expansion

Base metal

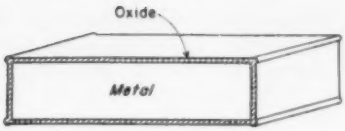
Composition, Grain size, Porosity, Alloy depletion, Intergranular penetration

■ To operate successfully at high temperatures engineering materials must retain their chemical stability and their strength. Except in a vacuum or inert atmosphere, most metals at high temperatures are invariably subject to corrosion by gases at high temperatures. For the purposes of this article the gases considered likely causes of corrosion are: 1) air, the most common, 2) sulfur-bearing atmospheres, such as are encountered in the processing or combustion of sulfurous materials, and 3) hydrogen atmospheres, such as in annealing furnaces.

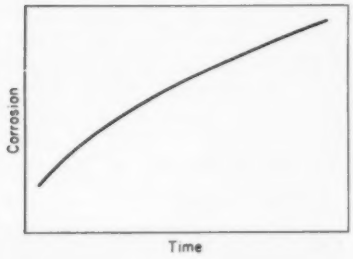
Almost all chemical reactions between a metal and a gas increase in rate with increasing temperature. Such reactions can cause rapid chemical deterioration in metals and accompanying mechanical failure. Unfortunately, it is difficult for a metal to have both good corrosion resistance and good strength at high temperatures. Both of these properties are related to chemical composition, and changes in composition that improve one property often detract from the other. The factors which control high temperature corrosion should be considered early in the design stage to insure best materials selection.

1. How corrosion products form

The chemical reaction that takes place between a metal and a gas at high temperatures always produces corrosion products. If the corrosion product is an adherent, external layer that grows by diffusion it can protect the underlying metal and actually decrease the rate of corrosion as the thickness of the layer increases. Such a condition is shown in the accompanying sketch which shows the shape of the oxide layer on a piece of Inconel. The amount of corrosion



that occurs as a function of time for this piece is shown in the accompanying graph. Note that



the shape of the curve is parabolic and that the corrosion rate decreases with increasing time.

Diffusion-controlled corrosion can be expressed mathematically

A simple mathematical equation can be used to describe diffusion-controlled corrosion. This equation relates the second power of the amount of corrosion to the time during which corrosion occurs, i.e.,

$$X^2 = k_1 t$$

where X = amount of corrosion, usually measured by a change in the weight or thickness of corrosion products
k_1 = a constant for a given temperature
t = the time during which corrosion occurs

Upon differentiation the above equation becomes:

$$dX/dt = k_1/2X$$

which shows that, at any time, the corrosion rate is inversely proportional to the amount of corrosion that has occurred up to that time. Such an equation does not apply to films of zero thickness since the corrosion rate would then be infinitely large. As shown in the previous graph, plots of experimental data on parabolic corrosion do not go through the origin. A transition is made to parabolic behavior only after a short time has elapsed and the film has been allowed to build up slightly.

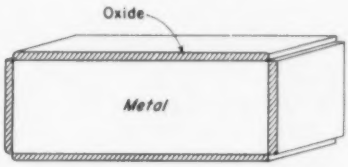
Some types of corrosion films show an even greater protective capacity than the parabolic type described above. Examples of such rate equations are:

$$X^3 = k_2 t$$
$$X = k_3 \log t + k_4$$
$$X = k_5 - k_6/t$$

Such equations can only be used under specific operating conditions, as in the case of the logarithmic equation which holds only for extremely thin films. They cannot be generally applied for all cases, since an alloy undergoing oxidation might obey one law for a certain time and at certain temperature conditions, and a different law at other times and temperatures.

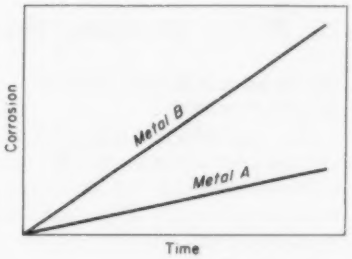
What happens when corrosion continues unchecked?

If the corrosion products formed in a gas at high temperature are porous and not adherent, they will provide no protection and corrosion will continue at an undiminished rate. Such a condition is shown in the accompanying sketch



which shows the non-protective oxide layer formed on columbium after exposure to air at 1110 F. Note the discontinuities at the edges.

The two metals whose corrosion rates are shown in the accompanying graph will continue



to corrode at a constant rate regardless of how thick the oxide layer is. These two metals are said to follow the linear corrosion rate law and are undesirable unless, of course, their corrosion rate is very low.

A corroding agent can attack

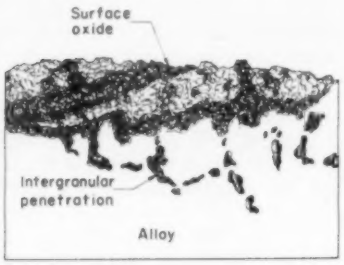
Rating Alloys Is Difficult

The difficulty in selecting corrosion resistant materials from available test data lies in determining whether or not the test conditions match the expected operating conditions. Often some important variables are not described or may not even be known. Although alloy composition and test temperatures are usually described, the kind of metal surface preparation and the amount of thermal cycling are often omitted. Also, the atmosphere is frequently described by a non-definitive term such as "slow-moving air." In addition, the corrosion rates themselves are sometimes vague and are often described as "slow," "medium" or "high." Despite these shortcomings, semi-quantitative or even qualitative data are helpful in eliminating the inferior alloys and indicating the promising alloys which merit further test.

The resistance of a large number of metals to a considerable variety of corrosive media are contained in the comprehensive National Assn. of Corrosion Engineers Publication 55-6 entitled "High Temperature Corrosion Data." Similar high temperature corrosion data can frequently be obtained from materials suppliers, the National Bureau of Standards, or Office of Technical Services reports. All of these data are intended to serve as an initial selection guide and are not meant to supplant actual use tests.

at local sites and cause pitting, or it may attack at grain boundaries where it destroys the integrity of the metal by separating the grains. Pitting implies that local areas are especially susceptible to chemical attack. Such local areas can result from impurities, from local depletion of components of the alloy, or from prestressed areas.

The appearance of 310 stainless steel which is attacked intergranularly during heating in air is shown in the accompanying sketch. Observe the surface



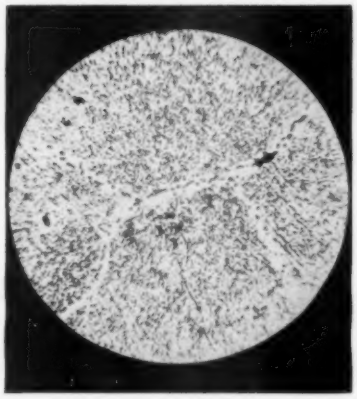
scale as well as the corrosion of the grain boundaries. Eventually entire grains will be cut out by the intergranular attack. This effect is even more pronounced when the corrosion products are voluminous and the metal grains are forced apart in addition to being undercut.

The size of grains is an important corrosion variable. Ordinarily, small grains have more boundary area and are more susceptible to attack. However, small grains can actually be less susceptible to attack, as is the case when sulfur reacts with nickel above the eutectic temperature in the nickel-sulfur system. A possible explanation for the low rate of attack is that the small grains offer a maze of intersecting paths which inhibit penetration by the corrodent. In contrast, large grains would provide relatively long, conductive paths which the fluid corrodent could easily follow.

Corrosion can occur internally as well as externally

Internal corrosion formations can occur whether or not any external corrosion products are formed. When an alloy is exposed to a gas at high temperature, components of the gas can dissolve in the alloy. If the alloy contains a material which can react with the dissolved gas, such a reaction will occur when the gas concentration reaches a certain limit. The reaction product will appear as a second phase dispersed throughout the alloy matrix and may markedly change its properties. The metal may become hard and brittle; however, in some cases its properties may even be improved. For example, the formation of internal or subscale cadmium oxide in a silver-cadmium alloy (see photo) can produce greater mechanical strength than the unoxidized silver matrix would ordinarily provide alone.

In addition to dissolving in the alloy, a gas can react with a specific material in an alloy to form volatile products. As this material is gradually used up at the surface, it is replaced by the same material which diffuses up from below the surface to sustain the reaction. Thus, almost all of that material can eventually be removed from the alloy, and the properties of the alloy consequently changed.



Formation of cadmium oxide *(dark spots) in a silver-cadmium alloy improves mechanical strength. The silver matrix remains unoxidized.*

2. Alloy composition determines corrosion products

Oxide products can protect the base metal

Surprisingly, the major constituents of an alloy do not necessarily make up the major portion of corrosion scale, and in some cases they do not appear at all. Therefore, to some extent it is possible to control and improve the composition of the corrosion scale by adding to the alloy small amounts of an element which will later appear in relatively large amounts in the scale.

Examples of such materials are the stainless steels which contain up to 25% chromium and 20% nickel, the nickel-base alloys such as Inconel or Nichrome which contain 15 to 20% chromium, and the chromium-iron alloys which can have as much as 27% chromium along with aluminum in some cases. In a high-temperature oxidizing atmosphere all of these materials tend to form an oxide of the Cr_2O_3 or Al_2O_3 type, or something more complex like the spinels, of which $NiCr_2O_4$ is a good example.

Such oxide deposits are desirable because they are adherent and prevent free access of the atmosphere to the alloy. The deposits slow down further oxidation by preventing oxygen from diffusing through to the base metal, and keeping metal from diffusing to the atmosphere.

Some oxides give little protection

If the rate of oxidation is extremely rapid ("catastrophic") it can completely destroy the base metal. Even materials with relatively high oxidation resistance can be made to oxidize rapidly, simply by adding small quantities

of elements such as vanadium or molybdenum. The severe influence of small quantities of these and a few similar elements is thought to be caused by their low melting points or by the volatility of their oxides. When these oxides evaporate or become liquid they cannot prevent the atmosphere from diffusing to the base metal and reacting with it. In some cases such a reaction can occur even if the oxides in the corrosion scale do not evaporate or become liquid. The formation of oxides of elements such as titanium, columbium, beryllium and zirconium has been found to be detrimental to the corrosion resistance of iron–25 chromium–5% aluminum and similar alloys exposed to air at 2200 F.

Minor elements can promote grain-boundary attack

Aside from the role they play in scale formation, the minor elements of an alloy can also determine how susceptible an alloy will be to grain-boundary attack by corrosive media. An example of this kind of behavior can be found among the stainless steels which contain carbon and which largely derive their corrosion resistance from their chromium content. When these steels are held in a critical temperature range (900 to 1600 F), chromium carbide forms, depleting the grains of their chromium content near the grain boundaries. Chromium depletion makes the steel sensitive to grain-boundary attack by corrosive media. Such sensitization occurs even though carbon content may be 0.1% or less. However, it can be prevented by adding titanium or columbium in respective amounts of at least 5 or 10 times the carbon content. Thus, titanium or columbium carbides are precipitated rather than chromium carbide. Consequently, the chromium is not depleted near the grain boundaries and its protective action is not lost. Where this kind of remedy is used, the materials are said to be stabilized, as in the case of types 321 and 347 stainless steel.

3. Gas composition and flow determine corrosion products

Major corrosion products can form from minor gases

Not only alloy composition but also the composition of the atmosphere determines what the corrosion products will be. The major constituents of the gas need not enter into the corrosion reaction at all, and small amounts of specific impurities can be quite important in speeding or slowing reaction rates. This theory is supported by the fact that most metals, when heated in air, form oxides rather than nitrides, even though the nitrogen content is nearly four times that of oxygen.

It might be expected that if oxygen is the corroding agent, corrosion could be stopped by using a reducing atmosphere or limiting the supply of oxygen. The use of a reducing atmosphere works in some cases, as shown by the bright and shiny surfaces of many metals that are heated in dry hydrogen. However, this technique is not a cure-all.

In many cases either it is not practical to remove the air, or else a small amount of oxidation may even be helpful in combating more rapid corrosion of another type brought about by some minor impurity in the atmosphere. The latter case is exactly what occurs when nickel is attacked by sulfur. The hydrogen sulfide formed in a reducing atmosphere can produce grain-boundary attack. This attack is accompanied by the formation of large amounts of nickel sulfide which tend to force the alloy grains apart. A similar type of failure might be expected in an oxidizing atmosphere containing sulfur dioxide. However, the rate of corrosion is actually slower in the oxidizing atmosphere than in the reducing atmosphere because the formation of some nickel oxide in the oxidizing atmosphere inhibits sulfur attack. If nickel must be used in a sulfur-bearing atmosphere at high temperatures, it can be made much more resistant by adding chromium, as in the case of the Inconel alloys.

Atmospheres do not always behave as expected

Before we take up this point let us define the three types of atmosphere that can be encountered in service.

Broadly speaking, any atmosphere is considered oxidizing with respect to a metal if one or more of its constituents react with the metal to form a new compound. This is true even if the compound formed does not contain oxygen. Typical oxidizing atmospheres are oxygen, the halogens, carbon dioxide and steam.

By common definition, a reducing atmosphere differs from an oxidizing atmosphere in that it reacts with a compound of the metal to yield back the metal itself. Examples of reducing atmospheres are carbon monoxide, ammonia and hydrogen.

A neutral atmosphere has no effect on the metal or its compounds. It may consist of pure noble gases such as helium or argon or, in certain cases, nitrogen in a vacuum.

The danger in using common definitions of this type is that atmospheres do not always behave the way they are expected to. An atmosphere can be changed with respect to the metal—from oxidizing through neutral to reducing—just by changing the temperature, or the composition of the alloy, or the atmosphere. Consequently, all of these factors must be known before an atmosphere can be typed, and general classifications of atmospheres as "oxidizing" or "reducing" are not always correct.

For example, consider a hydrogen atmosphere containing enough water to produce a dew point (water vapor content) of –40 F, and suppose this atmos-

phere passes over a piece of nickel and a piece of chromium, each at 1470 F. Normally, we would consider that this is a reducing atmosphere. The nickel will not form a surface oxide, and if an oxide film is already present the atmosphere will react with the oxygen in the oxide to form water and metallic nickel. Therefore, the atmosphere is *reducing toward nickel.* However, if an oxide film is present on the chromium, the hydrogen will not react with the oxygen in the chromium oxide to form chromium and water vapor. Instead, the water vapor already present in the hydrogen will react with the chromium to form more chromium oxide. Therefore, the atmosphere is *oxidizing toward chromium.* This same atmosphere can be made reducing toward chromium by raising its temperature to 1920 F or reducing its dew point to –75 F. Thus, we have a "reducing" atmosphere that is both reducing and oxidizing.

Gas pressure and flow also determine rate of corrosion

In some cases various theories can be used to predict the effect of gas pressure on corrosion rates. However, it is difficult to predict corrosion rates for metals such as zirconium, titanium, vanadium and columbium, as their oxidation rates can either increase or decrease while the pressure of the corroding atmosphere is being increased. In any event, identical pressures should be maintained if comparative corrosion tests are to be made.

Flow rate is an important corrosion factor when the corroding gas is a mixture of active and inactive agents at normal pressure. Less gas comes in contact with the surface at a slow gas flow. Thus, at a very slow flow the amount of active gas at a surface can become stagnant, and after it reacts with the metal there is no new supply of active gas to take its place. Thus, the inactive gas remaining produces a protective layer and the corrosion rate is greatly decreased. The corrosion rate when the gas is stagnant can be two to four times less than when the gas is flowing fast enough to prevent stagnation.

However, if the less active gas is able to react with the metal to some extent, maintaining a stagnant layer may result only in exchanging one undesired process for another. An example is the embrittlement of 446 chromium-iron in stagnant air through the formation of chromium nitrides after the oxygen has been depleted.

4. Some surface treatments can increase corrosion rates

Metals that are to be used at high temperatures can be surface treated in a variety of ways, such as rolling, machining, polishing, abrading, pickling or coating. The kind of surface preparation used can have a considerable influence on corrosion rates. For example a shiny surface that is pleasing to look at may not provide the best corrosion resistance. A metal such as Hastelloy oxidizes much more rapidly in air after it is cleaned with a bromine-methyl alcohol solution than it does when the surface is abraded. Also, certain iron-nickel alloys have been found to oxidize much faster in air when the surface is sand-blasted than when the surface is pickled.

Some inorganic and ceramic coatings are quite useful in preventing corrosion at very high temperatures. These coatings often have a tendency to crack and spall. However in many cases their adhesion can be improved by giving the base metal an initial pretreatment in the corroding atmosphere. The resulting thin corrosion product that is formed not only is adherent and protective to the base metal, but promotes adhesion of the coating material that is applied to it.

5. Thermal cycling and temperature affect protective films

Thermal cycling can destroy coatings

The resistance of metals to high temperature corrosion by gases is often markedly affected by the amount of thermal cycling that occurs. If protective corrosion products and coatings have a different coefficient of thermal expansion than the base metal, severe temperature changes will create stresses and cause the films to crack and fall off. Thus, corrosion is always likely to be more severe under thermal cycling conditions than at a constant temperature.

Some improvement in resistance to thermal cycling can be obtained by using a glass coating which softens and yields at high temperatures, or by locking the surface scale onto the base metal. The greatly increased life of Nichrome heating elements, for example, apparently occurs through the addition of rare earths which increase the adhesion of the protective corrosion products formed.

Temperature determines kind of reaction

Temperature determines the kind of reaction that will occur as well as the rate at which it will proceed. One reaction and its corresponding corrosion product may predominate at a given temperature. However, a rise in temperature can cause a second reaction to predominate that will produce a new and different type of corrosion product.

Materials
in Design Engineering

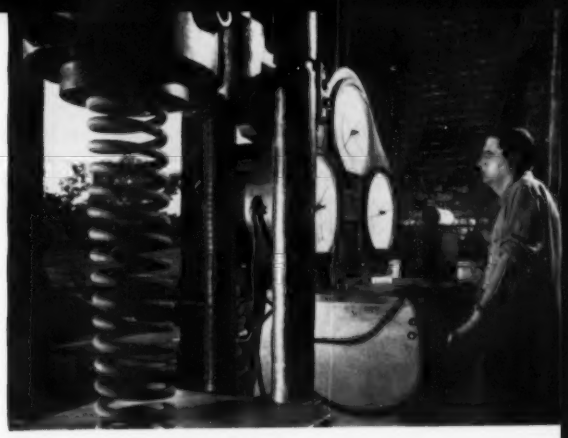
Manual No. 161
August 1959

Materials for Springs

A survey of the 35 most popular metal spring materials, including tabular comparisons. This manual gives detailed information on important design properties such as elastic moduli, elastic limits, allowable stress and temperature limits. It covers six major groups of materials:

- *Carbon steels*
- *Alloy steels*
- *Stainless steels*
- *Nickel alloys*
- *Copper alloys*
- *A cobalt alloy*

by John T. Milek, *Consulting Engineer, Los Angeles, Calif.*



Wide range of properties

Large and small sizes

Variety of designs

Photos courtesy Alco Products, Inc.

■ The three most important factors in selecting a spring are the type of spring needed (i.e., compression, torsion, etc.), the actual design of the spring itself, and the materials of which it is to be made. A good deal of information has been published on available spring types and spring design. However, despite many excellent scattered sources of information, data on spring materials are not readily available in one reference source.

The purpose of this article is to summarize the principal spring materials that are available and describe their important properties. Naturally, space does not permit a complete description of properties. It is recommended that the designer consult closely with a spring supplier before making his final selection.

Spring materials can be divided into the following six main groups: carbon steels, alloy steels, stainless steels, nickel alloys, copper alloys, and a cobalt (Elgiloy) alloy. Each of the principal materials in these groups is described in this manual. In general:

- The highest stressed springs are usually made from music wire or chromium-vanadium steel.
- The carbon steels are quite popular because of their low cost.
- Stainless steel, phosphor bronze and beryllium copper perform very well in applications requiring high corrosion resistance.
- Alloys such as Inconel, Inconel X and 17-7 PH stainless steel provide excellent service where high temperatures are involved.
- If high accuracy with temperature changes is needed, one of the constant modulus alloys such as Ni-Span C, Iso-Elastic or Elinvar should be considered.

Carbon steels

1055, 1060

Low in cost

Good for general purpose uses

SAE 1055 and 1060 carbon steels are good quality, low cost spring materials which are quite useful in general purpose applications where high grade expensive steels are not required. They are satisfactory for low-stressed helical and flat springs but are not generally desirable for torsion springs. They should not be used where long fatigue life is needed or where temperature exceeds 250 F.

The two steels are readily available in wire diameters from 0.031 to 0.5 in., and are satisfactory where commercial tolerances are permitted. Spring properties (properties of all the carbon steels are listed in Table 1) of the materials are produced by cold reduction of the wire. Flat springs are sometimes made from annealed stock.

1065 oil tempered

Good shock and impact resistance

Long fatigue life at high stresses

This is a general purpose spring steel which, in addition to the above advantages, can be used at temperatures up to 425 F. Also, it is moderately priced and is an excellent material for springs without severe bends. It is a better spring material than hard drawn spring steel, but not as good as music wire. It is less resistant to the effects of plating and is slightly more expensive than hard drawn wire.

The material is cold drawn to the desired size and then heat treated by a continuous tempering method. The springs are coiled and formed from this hardened material. A low temperature stress relief is all that is required after processing; this final heat treatment (1½ hr at 450-650 F) relieves the stresses set up in coiling and hooking.

Oil tempered valve spring steel is the same material as oil tempered spring wire except that greater care is spent on controlling the surface of the wire. Reduced surface defects and improved heat treatments give this material longer life than ordinary oil tempered spring steel (see Fig 1 and 2 for fatigue properties).

A Look at Plastics Springs

Much attention has been devoted in recent years to the development of plastics materials for springs. In addition to their high corrosion resistance plastics springs are fairly easy to fabricate, have good dimensional and structural stability, are nonmagnetic, and have low electrical and thermal conductivity. However, their strength cannot compare with that of metal springs. Most applications of plastics springs to date have been largely experimental, and their future appears to lie in low strength applications where special properties are needed.

One of the most successful applications of plastics springs has been their use in an electromagnetic vibratory feeder (for description see M/DE, Apr '58, p 144). The spring system of this feeder consists of two flat disk-shaped plastics springs and one cantilever leaf spring, all made of a controlled filament, glass-fiber-reinforced epoxy laminate. Alternating plies of the laminate are oriented at 90 deg to provide isotropic strength characteristics.

A number of experimental reinforced plastics helical springs have been developed at the National Bureau of Standards. Various combinations of resins (notably epoxy and polyester) have been used in conjunction with various reinforcements (including chromium-finished glass roving, braided and ribbon glass tape, and nylon filament). Of these combinations, the best spring material appears to be an epoxy resin reinforced with double rows of glass roving. Including the Wahl correction factor, this promising composite material has a modulus of 1,000,000 psi, as contrasted to 250,000 psi for the unreinforced material.

TABLE 1—PROPERTIES OF CARBON STEEL SPRING MATERIALS

Type →	1055, 1060	1065 Oil Tempered	1065 Hard Drawn	1085 Music Wire	1095 High Carbon
PHYSICAL PROPERTIES					
Density lb/cu in.	0.284	0.284	0.284	0.284	0.283
Coef of Ther Exp, 10^6 per °F	6.2 (77-212 F)	6.6	—	6.5 (68 F)	6.3 (68-212 F, ann.)
Elec Res, microhm-cm	—	—	—	11	18
Max Service Temp, F	—	425	250	250	250
MECHANICAL PROPERTIES					
Rockwell Hardness	—	C42-46	C41-45	—	C40-52
Mod of Elast in Tension, 10^6 psi	30	29-30	30	29-30	30
Temp Coef of Mod of Elast, per °F	—	-190×10^{-6}	-342×10^{-6}	-190×10^{-6}	—
Mod of Rigidity, 10^6 psi	11.5	11.5	11.5	11.5-12	11.5
Temp Coef of Mod of Rigidity, per °F	—	-140×10^{-6}	—	-145×10^{-6} (−4 to 122 F)	—
Ten Str (in. wire dia in paren), 1000 psi	271-311 (0.028) 167-193 (0.375) 147-170 (0.625)	281 (0.028) 175-205 (0.375) 165 (0.5)	271 (0.028) 167 (0.362) 156 (0.5)	See Fig 3	See Fig 6
Elastic Limit, 1000 psi[a]					
Tension	120-180	—	100-200	150-350	150-310
Torsion	—	80-130	75-130	90-180	—
Allowable Str for Helical Compr Springs, 1000 psi[b]					
Light Service	—	80	—	100	80
Average Service	—	65	—	85	70
Severe Service	—	55	—	70	60

[a]Varies with wire dia.
[b]These design stress values include Wahl Factor and are subject to following general adjustments: a) wire dia under 0.02 in.—increase by 20%; 0.02 to 0.057 in.—increase by 10%; b) compression springs—increase by 10-15%; c) torsion, flat and cantilever springs—increase by 50-75%; d) extension springs—reduce by 10-20%; e) suddenly applied loads—reduce by 50%.

1065 hard drawn

Low in cost

Readily plated

Good for general purpose uses

This hard drawn carbon steel is commonly used for general purpose springs where cost is an important factor. It can be readily electroplated and is popular where long life and accurate loads and deflections are not too important. It should not be used at sub-zero temperatures or above 250 F.

SAE 1065 spring steel is made the same way as music wire, but less care is taken in processing the material and in maintaining uniform chemical composition. Cold working gives the wire all its spring properties. Compared to music wire, the material has a considerably lower elastic limit but about the same moduli of elasticity and rigidity.

1085 music wire

Very high tensile strength

Good fatigue resistance

Higher quality but higher cost than other carbon steels

Music wire is one of the best, toughest, and most widely used materials for small springs. It has the highest tensile strength (see Fig 3) and can withstand higher stresses under repeated loading than any other spring material. It is not recommended for temperatures below zero or above 250 F.

Music wire is recommended for most mechanical springs having a wire size less than 0.028 in., and it can be used in sizes up to ⅛ in. where high strength and good surface finish are needed. Music wire can be easily plated and is obtainable pretinned or preplated with cadmium. Plating after forming is preferred, especially when salt spray resistance is required. The fatigue life of music wire is excellent (see Fig 4 and 5), which is the main reason it has become so popular in recent years.

Music wire is generally reduced about 80% in eight to ten drawing passes. Upon being formed into springs and heated to 375-425 F, it will actually increase in hardness and tensile strength. If treated at 700-725 F, its physical properties drop slightly, but its heat resistance and fatigue properties are improved. Formed music wire springs that are stress relieved at 750 F have about the same fatigue properties and resistance to load loss at high temperatures as valve spring wire.

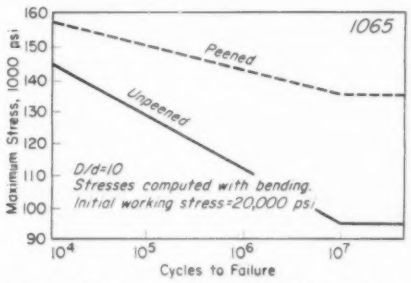


***Fig 1**—Fatigue strength of 1065 carbon steel (valve spring quality).*

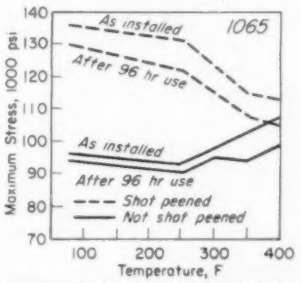


***Fig 2**—Endurance limit of 1065 carbon steel at elevated temperatures.*

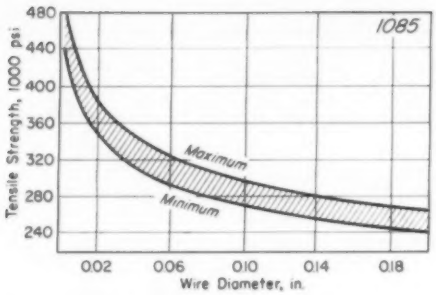


***Fig 3**—Tensile strength of cold drawn 1085 music wire as it varies with wire diameter.*

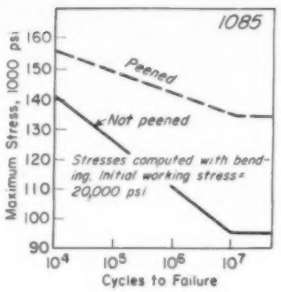


***Fig 4**—Fatigue strength of 1085 music wire at room temperature.*

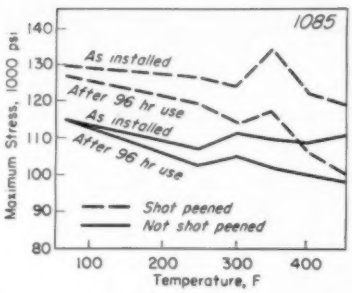


***Fig 5**—Endurance limit of 1085 music wire at elevated temperatures.*

1095 high carbon

Useful for clock and motor springs

Not readily formed

SAE 1095 high carbon (0.9 to 1.04%) steel is extensively used for clock and motor springs. It is also useful for instrument springs and flat springs which do not require much forming. Because of the material's limited forming properties, spiral and clock springs must usually have their end sections annealed to facilitate bending and piercing.

The steel is not used where good torsional properties are needed (for tensile strength, see Fig 6). Because of its high carbon content it achieves maximum hardness in the as-quenched condition. Cold forming is limited to flat stampings and springs coiled from small diameter wire. Maximum service temperature in the spring tempered condition is 250 F.

TABLE 2—PROPERTIES OF ALLOY STEEL SPRING MATERIALS

Type ➡	6150 Chromium-Vanadium	9254 Chromium-Silicon	9260 Silicon-Manganese	18-4-1 Tool Steel
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.284	0.284	0.284	0.284
Coef of Ther Exp, 10^6 per °F	8.1 (70-1200 F)	—	—	—
Elec Res, microhm-cm	21	—	—	—
Max Service Temp, F	750 (at low stresses) 400 (at high stresses)	—	—	800 (at low stresses)
MECHANICAL PROPERTIES				
Rockwell Hardness	C44-53	C49	C42-52	C52-53
Mod of Elast in Tension, 10^6 psi	29-30	30	29	—
Temp Coef of Mod of Elast, per °F	-146×10^{-6}	—	—	—
Mod of Rigidity, 10^6 psi	11.2-11.5	11.5	10.75	—
Temp Coef of Mod of Rigidity, per °F	-144×10^{-6}	—	—	—
Ten Str (in. wire dia in paren), 1000 psi	300 (0.032) 200 (0.394)	285-305 (0.035)[c] 225-245 (0.375)[c]	200-250 in tension 140-175 in torsion	See Fig 11
Elastic Limit, 1000 psi[a]				
Tension	180-230	220-300	180-230	—
Torsion	100-130	130-160	100-130	—
Allowable Str for Helical Compr Springs, 1000 psi[b]				
Light Service	85	90	82	—
Average Service	75	80	70	—
Severe Service	60	60	57	—

[a]Varies with wire dia.

[b]These design stress values include Wahl Factor and are subject to following general adjustments: a) wire dia under 0.02 in.—decrease by 20%; 0.02 to 0.057 in.—increase by 10%; b) compression springs—increase by 10-15%; c) torsion, flat and cantilever springs—increase by 50-75%; d) extension springs—reduce by 10-20%; e) suddenly applied loads—reduce by 50%.

[c]Regular temper, R_c 49.

Alloy steels

6150 chromium-vanadium

Good fatigue properties

Good for highly stressed springs subject to extreme shock

This is the most popular alloy spring steel for springs that are required to withstand a large number of operating cycles (see Fig 7 and 8). It is a medium carbon steel with chromium and vanadium added to increase its hardness and tensile strength (see Table 2 for properties of alloy steels). It can be obtained either oil tempered or annealed; the pretempered material is best for valve or gun springs.

Springs of 6150 can be used at extremely high stresses in applications where they will also be subject to extreme shock and impact loading. For springs of high endurance, the alloy is usually used at a hardness of Rockwell C44-49; where extreme stresses and short life are expected, the hardness is increased to Rockwell C50-53.

In sizes ⅜ in. and under, 6150 alloy springs have no higher endurance limits than plain carbon steels of valve spring quality. However, the alloy springs have less tendency

to relax at temperatures as high as 400 F, at fiber stresses up to 100,000 psi. Satisfactory operation is obtained even up to 750 F when loads are not severe, when the stress range is narrow, or when stress changes are infrequent.

9254 chromium-silicon

Performs well when highly stressed

Resists shock

Has long life

This alloy is noted for its high hardness and good performance at extremely high stresses. Because of its heat resistance and hardness, the alloy can be used in valve springs and automotive transmissions at temperatures over 275 F. The alloy was developed originally for recoil springs in anti-aircraft guns where high resistance to shock loads and long life were needed.

The endurance limit (see Fig 9 and 10) of the 9254 alloy either before or after shot peening equals that of carbon steel in the same condition. At a given stress value, it can be used at a temperature 100 °F higher than the 6150 alloy and at higher hardnesses without breaking. The 9254 alloy provides excellent service for short life applications (5000 to 100,000 cycles). It can be coiled into springs with a D/d ratio (main spring dia to wire dia) of 5:1 at a hardness of Rockwell C52. After forming and heat treatment the alloy should be given a magnetic particle inspection for hardening cracks or other surface defects.

9260 silicon-manganese

High tensile strength

Better heat resistance than carbon steels

At one time 9260 was principally used for the large front suspension springs of automobiles. However, as a result of continued development during World War II, the high strength alloy is now available in a wider range of sizes. When used in a diameter as small as 0.035 in., the hardened alloy has a tensile strength of 300,000 psi and a hardness of Rockwell C50-54. As its diameter is increased to ⅝ in., the alloy's tensile strength drops to 250,000 psi.

If all conditions are equal, 9260 can be interchanged with the 9254 chromium-silicon alloy. Its resistance to heat, especially up to 450 F, exceeds that of carbon steel. It can be obtained hot or cold rolled, or in the drawn condition, and can be used as a lower cost material in place of the 6150 chromium-vanadium alloy. Round, square and rectangular sections in both annealed and pretempered conditions are obtainable in sizes from 0.031 to 0.5 in.

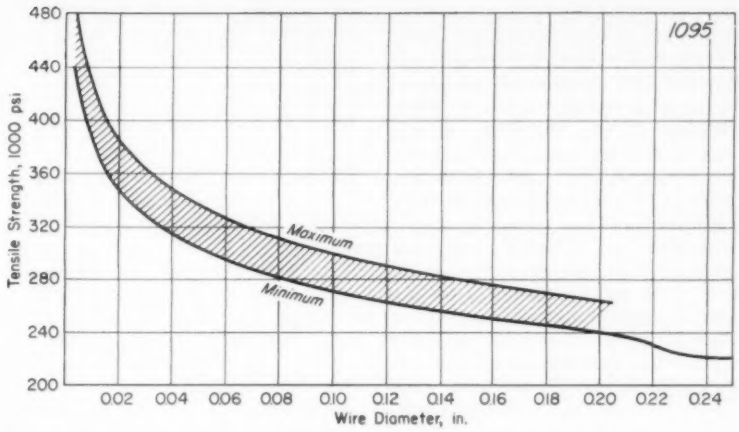


Fig 6—*Tensile strength of 1095 carbon steel vs wire diameter.*

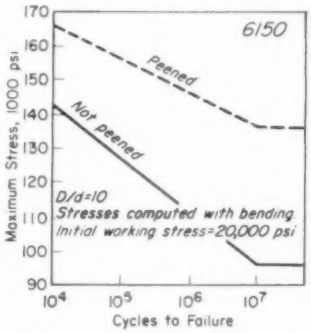


Fig 7—*Effect of shot peening on fatigue strength of 6150 chromium-vanadium steel.*

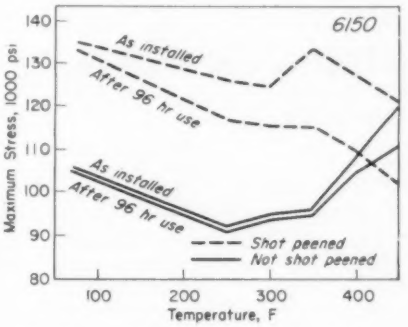


Fig 8—*Endurance limit at elevated temperatures of 6150 chromium-vanadium steel (0.142-in. wire).*

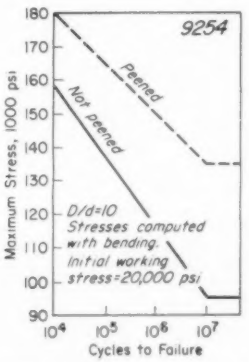


Fig 9—*Fatigue strength of 9254 chromium-silicon spring steel.*

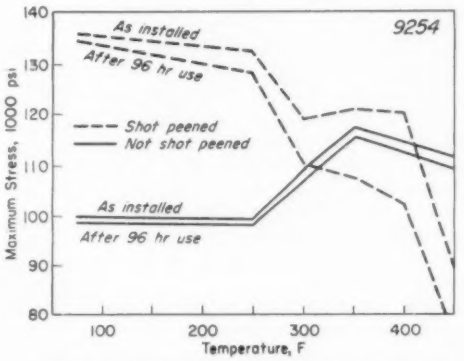


Fig 10—*Endurance limit of 9254 chromium-silicon steel springs at elevated temperatures.*

18-4-1 tool steel

Good high temperature properties

Limited availability

A limited amount of research has been done on the spring properties

of high speed 18-4-1 (18 tungsten-4 chromium-1% vanadium) tool steel. The alloy is known for its hardness retention at high temperatures and its ability to be heat treated to various tempers. It is reported in the literature that 18-4-1 springs can withstand a total combined stress of 40,000 psi at 700 F, and that by cutting this stress in half it is possible to use the springs at 800 F. The limited data available on the alloy (see Fig 11 and 12) indicate that it has favorable properties at high temperatures. However, the alloy is not available in very many shapes and sizes.

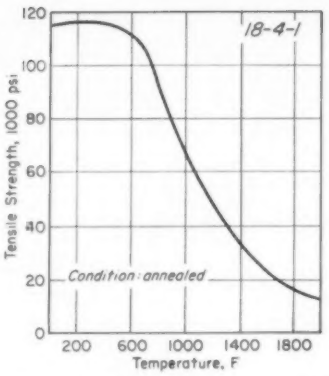


***Fig 11**—Tensile strength of high speed tool steel (18-4-1) at elevated temperatures.*

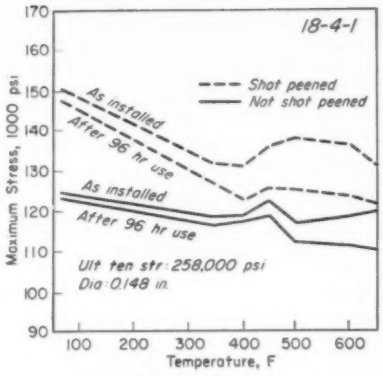


***Fig 12**—Endurance limit of 18-4-1 at elevated temperatures.*

Stainless steels

Type 302

Good strength at moderate temperatures

Good corrosion resistance

Type 302 is a general purpose, nonmagnetic, austenitic alloy with good corrosion resistance (general properties of 302 and other stainless steels are given in Table 3). For spring applications it is generally furnished in the cold rolled or drawn condition in diameters from 0.003 to 0.375 in. Its tensile strength varies from a minimum of 140,000 psi for the large size to 320,000 psi for the small size (see Fig 13).

Type 302 springs have good strength at moderate temperatures. If properly treated after forming they will set less than other spring steels (except high speed steel) at 500 F. However, the amount of set produced at 600 F sometimes precludes use of the material for accurate springs.

The alloy is nonmagnetic in the annealed condition; however, drawing or rolling of wire forms causes some transformation to martensite. Consequently, the smaller wire sizes tend to be magnetic.

The fatigue and strength properties of 302 stainless steel springs can be improved by shot peening (see Fig 14). However, it must be remembered that the initial gain in properties produced by shot peening is reduced after prolonged exposure at high temperatures.

One trouble encountered with type 302 is that its modulus varies with different mill practices. The higher the springs are heated after forming, the more this fault is corrected and the closer the steel approaches its true modulus of 28 x 10^6 psi in bending and 10^7 psi in torsion. (A comparison of the moduli of rigidity and elasticity of three widely used stainless steels with other popular spring materials is given in Fig 15 and 16.)

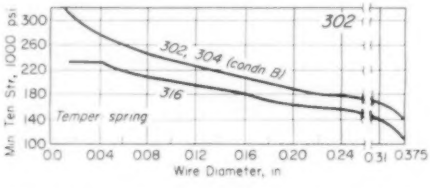


***Fig 13**—Variation of tensile strength with wire diameter for types 302, 304 and 316 stainless steels.*

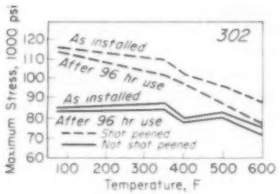


***Fig 14**—Endurance limit of type 302 stainless steel at various temperatures.*

TABLE 3—PROPERTIES OF STAINLESS STEEL SPRING MATERIALS

Type ➡	302	304	316	414	17-7PH
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.288	0.287	0.288	0.288	0.277-0.282
Coef of Ther Exp, per °F	9.6	8.4	—	5.8	6.1-8.5
Elec Res, microhm-cm	72	72	74	70	87
Max Service Temp, F	550	700	—	550	1000
MECHANICAL PROPERTIES					
Rockwell Hardness	—	42-47	35-45	43-48	45-50
Mod of Elast in Tension, 10^6 psi	26.5-29	28	28	28.5	29.5
Temp Coef of Mod of Elast, per °F	-200×10^{-6}	—	—	—	—
Mod of Rigidity, 10^6 psi	8.5-10	10	10	10.5	11
Temp Coef of Mod of Rigidity, per °F	-220×10^{-6}	—	—	—	—
Ten Str (in.wire dia in paren), 1000 psi	See Fig 14	See Fig 14	See Fig 14	120[b]	260-350 (0.03) 192-265 (0.44)
Elastic Limit, 1000 psi[a]					
Tension	60-260	60-260	130-200	—	—
Torsion	66-150	45-140	80-130	—	—

[a]Varies with wire dia. [b]Heat treated condition.

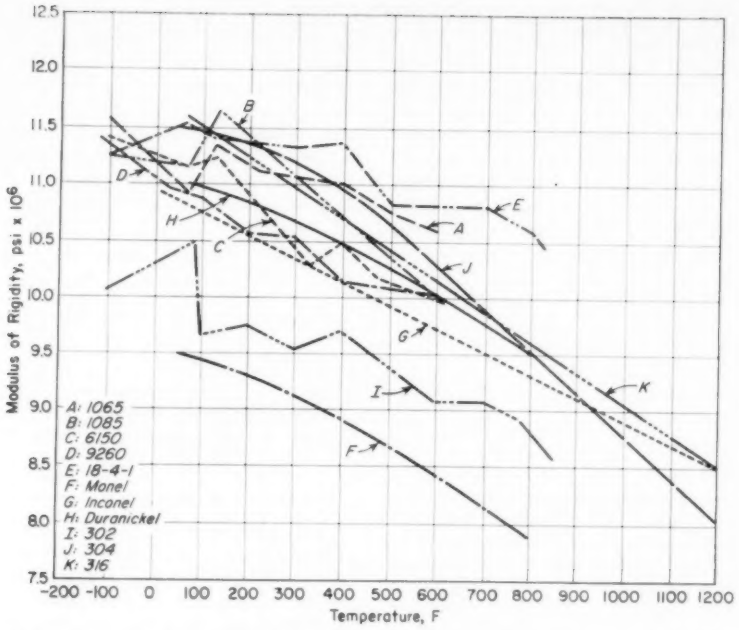


***Fig 15**—Variation of modulus of rigidity with temperature for 11 different spring materials.*

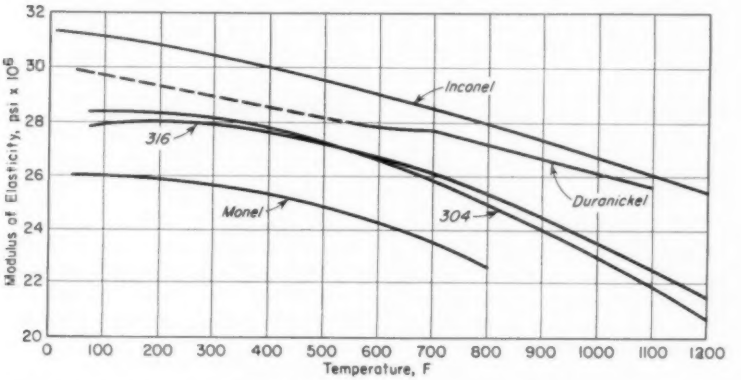


***Fig 16**—Change in modulus of elasticity of five spring materials as a function of temperature.*

Type 304

High in tensile strength

Usable up to 700 F

Type 304 is a nonmagnetic austenitic stainless steel that is somewhat superior to type 302 in corrosion resistance. It cannot be hardened by heat treatment, but it can be work hardened to extremely high tensile (see Fig 13) and yield strengths. The alloy has better bending properties and is easier to draw than type 302, and has roughly the same tensile strength.

Although type 304 stainless steel is resistant to oxidation at temperatures up to 1650 F, its maximum service temperature in spring applications is 700 F. A special 304L alloy with a low carbon content (0.03% max) is available to prevent carbide precipitation. Although the alloy is nonmagnetic in the annealed condition, it becomes slightly magnetic when cold worked.

Type 316

Good strength at high temperatures

High corrosion resistance

Type 316 is similar in composition to type 302 except for its slightly higher nickel content and the addition of about 2% molybdenum. The alloy is less magnetic than type 302 in the spring temper, and has even better corrosion resistance. Type 316 is preferred by the military for aeronautical springs even though its tensile strength (see Fig 13) is 10 to 15% lower than that of type 302.

The alloy has good cold working properties and can be used for rather severe cold forming operations. It exhibits good short time tensile and creep strength properties at elevated temperatures.

Type 414

Good corrosion resistance for general purpose uses

Poor low temperature properties

Type 414 is a straight chromium, low nickel, heat treatable, martensitic stainless steel which is in general use for springs. It is coiled and formed in the annealed condition and then hardened in a manner similar to carbon steels. It is magnetic and does not have the so-called "stainless" quality until after it has been heat treated.

Under relatively low stresses, type 414 can be used up to 550 F with a load loss of less than 10%. Its tensile strength is about 15% lower than that of type 302. Stress values between 40,000 and 60,000 psi (including curvature correction factor) have been used quite frequently with excellent results.

Type 414 springs are unsatisfactory for sub-zero application because of their brittleness and inability to withstand shock or impact loading at low temperatures. The alloy is generally recommended for springs with wire diameter greater than $\frac{3}{16}$ in. or for smaller wire sizes where the diameter ratio (D/d) is less than 4. Hard rolled 414 strip is frequently used for flat springs without further hardening.

17-7 PH

Long life under severe service conditions

Excellent high and low temperature properties

Type 17-7 PH stainless steel is an excellent spring material combining the high mechanical properties of music wire with the outstanding corrosion and heat resistance of the austenitic stainless steels. The alloy

is an excellent material for all kinds of springs where long life is required under severe service condition—high or low temperatures or corrosive atmospheres. It has excellent fatigue properties, reasonable ductility, and high yield strength, modulus of elasticity and strength-to-weight ratio.

At room and elevated temperatures, 17-7 PH has higher strength than beryllium copper and many nickel alloys. It retains a good portion of its strength in the 500 to 600 F range and stands up well at 800 F. The maximum service temperature of 17-7 PH helical compression springs is about 100 to 150 °F higher than that of type 302 stainless and close to that of Inconel X (17-7 PH has a much higher endurance limit than Inconel X).

Type 17-7 PH has good dimensional stability, and spring dimensions are unaffected by hardening treatments. Springs heated to 1000-1050 F to remove working stresses still retain their good spring properties. This treatment results in a constant spring rate. Springs of 17-7 PH show less relaxation than those of type 302 stainless and slightly more than those of Inconel X.

Nickel alloys

Monel

Lowest cost but lowest strength of nickel alloys

Good corrosion resistance

The nickel-copper monel alloy is a popular spring material because of its high strength and resistance to alkalis and many acids. It is one of the least expensive of the nickel spring alloys and is suitable for moderately and lightly loaded springs operating under corrosive conditions. It can be used over a temperature range of –100 to 425 F at normal operating stresses. Optimum resistance to oxidation is produced by a 1-hr stress-equalizing anneal at 650 F.

The tensile strength of monel ranges from 100,000 to 160,000 psi in wire sizes up to 3/16 in. dia (properties of the nickel alloys are given in Table 4). Larger sizes and strip are obtainable with lower tensile strengths. Hard temper strip can be used for applications such as flat springs and valve springs.

K monel alloy can be used instead of monel where better mechanical properties and slightly better high temperature properties (K monel is usable to 450 F) are needed. K monel is available in larger wire sizes than monel and, like monel, is essentially nonmagnetic.

Inconel

Good strength to 700 F

High corrosion resistance

Inconel (approx 75 nickel–13 to 16 chromium–9% iron) is especially noted for its corrosion resistance, strength, and resistance to oxidation at high temperatures. Inconel springs can be used down to –40 F and give good performance up to 700 F when designed for average or slightly lower stresses. At 700 F the loss of load is less than 5% in 48 hr. Recent tests have indicated the possibility of using the alloy at 900 F under special conditions with some set allowed.

Inconel derives its high tensile strength and hardness from cold drawing or cold rolling; it cannot be hardened by heat treatment. Wire up to ¼ in. dia has the best tensile properties.

Inconel X

Usable up to 1200 F

High in strength and corrosion resistance

This alloy is quite similar in composition to Inconel except that it contains small amounts of titanium, columbium and aluminum which make it precipitation hardenable. It is noted for its high strength at elevated temperatures and its resistance to chemical corrosion and oxidation. It can be used up to 1000 F for prolonged periods and up to 1200 F for short periods where corrosive or oxidizing conditions exist.

Inconel X acquires its excellent spring properties by a combination of heat treatment and cold working. Spring wire is ordinarily furnished with about 15% cold reduction (No. 1 temper) corresponding to a tensile strength of about 140,000 psi. After heat treatment tensile strength is raised to about 200,000 psi. Tensile strengths approaching 300,000 psi can be obtained by heat treating heavily drawn cold spring wire after heat treatment. Inconel X wire has been drawn down to diameters as small as 0.005 in.

Permanickel

Good in electrical conductivity and corrosion resistance

Usable up to 600 F

Permanickel is a relatively pure (98%) form of nickel with enough alloy content to make it age hardening. It occupies a place between K monel and Inconel, and can be cold worked and heat treated. As drawn to spring temper, its tensile strength ranges from 150,000 to 200,000 psi, and it is quite usable for many spring applications without further heat treatment.

Duranickel

Good in resistance to fatigue and corrosion

Usable up to 650 F

Duranickel is an age hardenable 93.7 nickel–4.4% aluminum alloy which has the excellent corrosion resistance that is characteristic of nickel plus added strength and hardness. This spring wire can be cold drawn and subsequently age hardened to develop a tensile strength of about 225,000 psi. The alloy can be used in the as-drawn condition for some spring applications.

Duranickel is about as corrosion resistant as pure nickel and will withstand higher stresses than Inconel. Springs made from both wire and strip have good resistance to fatigue and provide excellent service under many corrosive conditions at room temperature. The springs can be used up to 650 F; they have been effectively used in toasters at 600 F. Other popular applications include diaphragms, bellows, flapper valve disks, snap switch blades, flexible bridges in phonograph pickups, hands and numbers on watches used by the blind, and various parts in telautograph equipment.

TABLE 4—PROPERTIES OF NICKEL ALLOY SPRING MATERIALS

Type →	Permanickel	Duranickel[c]	Monel[c]	Inconel[f]	Inconel X	Constant Modulus Alloys	
						Iso-Elastic	Ni-Span C
PHYSICAL PROPERTIES							
Density, lb/cu in.	0.316	0.298	0.319	0.307	0.298	0.292	0.294
Coef of Ther Exp, 10^6 per °F	7.2 (70-212 F)	7.2 (77-212 F)	7.9 (70-400 F)	5.6[a]	8.3 (70-1000 F)	4[a]	4.5 (—50 to 150 F)
Max Service Temp, F	600	650	425	700	1200	—	700
MECHANICAL PROPERTIES							
Rockwell Hardness	—	—	—	C30-40	—	C30-36	to C42
Mod of Elast in Tension, 10^6 psi	30	30	26	31	31	26	24
Temp Coef of Mod of Elast, per °F	—	—	—	—	—	-20 to 15 x 10^{-6}	-10 to 10 x 10^{-6}
Modulus of Rigidity, 10^6 psi	11	11	9.5	11	11	9.2	9.4-9.8
Min Tensile Str (in. wire dia in paren), 1000 psi							
As Drawn	—	170 (<0.028), 150 (0.229-0.312), 125 (0.5-0.563)	160 (<0.058), 140 (0.115-0.313), 120 (0.501-0.625)	200 (<0.029), 185 (0.23-0.313), 170 (0.439-0.500)	—	—	—
Age Hardened	—	205 (<0.028), 190 (0.229-0.312), 170 (0.5-0.563)	170 (<0.058), 150 (0.115-0.313), 130 (0.501-0.625)	—	220 (for most sizes)	—	—
Elastic Limit, 1000 psi[b]							
Tension	130-170	—	85-125	—	90-150	102	—
Torsion	60-90	—	50-70	—	50-90	60	—
Allowable Str for Helical Compr Springs, 1000 psi[c]							
Light Service	65	70	60	75	75-100	—	62
Average Service	55	60	50	65	55-80	—	54
Severe Service	40	45	40	50	50	—	44
Endurance Limit (10,000 cycles), 1000 psi[d]							
As Coiled	45	45	45	50	—	—	—
Shot Peened	60	60	60	75	—	—	—

[a]Room temp. [b]Varies with wire dia.
[c]These design stress values include Wahl Factor and are subject to following general adjustments: a) wire dia under 0.02 in.—increase by 20%: 0.02 to 0.057 in.—increase by 10%; b) compression springs—increase by 10-15%; c) torsion, flat and cantilever springs—increase by 50-75%: d) extension springs—reduce by 10-20%; e) suddenly applied loads—reduce by 50%.
[d]20,000 psi initial stress. [e]Tensile strength values are for spring temper wire.
[f]Tensile strength values for spring temper wire after stress relieving.

Constant modulus alloys

Maintain constant load during temperature change
Have good corrosion resistance

The constant modulus alloys usually contain high percentages of nickel and are desirable for springs that must exert uniform loads and deflections during changes in temperature. Because of their low thermoelastic coefficients, the alloys eliminate the variations in spring stiffness caused by changes in modulus with temperature.

The alloys are also corrosion resistant and have low mechanical hysteresis and creep values. For these reasons they are preferred for food weighing scales, precision instruments, gyroscopes, measuring devices, recording equipment and computing scales over a fairly wide temperature range.

Constant modulus alloys are quite expensive and are not regularly stocked in a wide variety of sizes. Special processes are required in manufacturing the springs and it is recommended that they be specified only after consulting with the spring supplier.

Iso-Elastic—This alloy (36% nickel, 8% chromium, balance iron) is well suited for precision instruments because it has good corrosion resistance, a low temperature coefficient of modulus of elasticity, a drift error of less than 0.02%, and a hysteresis error less than 0.01% of total spring deflection. Safe torsional stresses of 40,000 to 60,000 psi are used with Rockwell hardnesses of C30 to C36. Recommended temperature range is –50 to 150 F. The alloy is not ordinarily supplied in the unfabricated state, as careful processing is required to obtain its spring properties. It is not heat treatable.

Ni-Span C—One of the principal advantages of Ni-Span C (41-43% nickel, 4.9-5.5% chromium, 2.4% titanium, balance iron and other elements) over other constant modulus alloys is that it is a precipitation hardening alloy which, after suitable heat treatment, develops unusually high physical and mechanical properties. Heat treatment can be

carried out either in the soft annealed or cold worked conditions, the latter giving the best properties.

In addition to its excellent thermoelastic properites, Ni-Span C is noted for its low hysteresis and good mechanical damping properties. Although it has not been advocated as a high temperature spring material, the alloy can be used at temperatures up to 650-700 F at working stresses of 40,000 to 50,000 psi for otherwise ordinary service conditions. It has good corrosion resistance, though not as high as some stainless steels.

Elinvar—This alloy (33-35% nickel, 5-21% chromium, 53-61% iron) is useful for constant modulus springs over a temperature range of –150 to 300 F. It has high resistance to oxidation and corrosion, is immune to magnetic effects, and has low thermal expansion.

Elinvar is austenitic and can only be hardened by cold working. Its elastic limit is about 45,000 psi, but it is usually used at considerably lower stresses. Principal applications for the alloy are scale springs, hair springs, watch springs, bourdon tubes, tuning forks and similar uses.

Copper alloys

Phosphor bronze

Good corrosion resistance

High electrical conductivity

Because of its good corrosion resistance and conductivity, phosphor bronze is one of the most popular copper alloys for springs (see Table 5 for properties). The two most widely used grades are Grade A (95% copper, 4.75% tin, 0.25% phosphorus) and Grade C (92% copper, 7.75% tin, 0.25% phosphorus). Since addition of tin raises strength, C alloy is usually preferred where high mechanical properties are needed. However, because of its lower cost the A alloy is usually used where strength is not an important design factor.

The properties of phosphor bronze springs can be improved considerably by shot peening. Tests show that a compression spring with a 20,000 to 35,000 psi stress range (and a design life less than 10^7 cycles) can have its stress range increased to 20,000 to 50,000 psi by shot peening.

Phosphor bronze does not have good high temperature properties and should not be used above 225 F at stresses over 20,000 psi. Also, even though it has good corrosion resistance it should not be used in salt atmospheres.

Phosphor bronze is available in both wire and flat forms. The flat strip can be readily stamped and blanked to produce parts with good spring properties. The alloy is widely used in switch spring contacts that must carry electrical current. Because of its resistance to arcing it is also quite popular for circuit breakers, controllers and signalling devices.

Beryllium copper

High conductivity

Good mechanical properties

Wider temperature range than other copper alloys

Beryllium copper is an especially popular spring material for electrical applications because of its combination of good mechanical properties, electrical and thermal conductivity, and resistance to wear and corrosion. It is the best electrical conductor of any spring alloy of comparable hardness, and is stronger and more fatigue resistant than the other copper-base spring alloys. Fatigue strength can be markedly increased by shot peening.

This alloy resists common acids, salts, and sea and fresh water almost as well as pure copper. Like most copper alloys, beryllium copper can be used at sub-zero temperatures. It has a higher operating temperature than other copper alloys and retains good spring properties up to 300 F.

Beryllium copper wire is generally supplied in the half-hard temper, requiring heat treatment. It has sufficient ductility to be used in cold forming compression, extension and torsion springs. Solution annealed wire is also supplied but is not generally recommended for springs.

Beryllium copper springs are readily formed in the annealed or in the annealed and cold worked condition. They are subsequently given a simple low temperature heat treatment which doubles strength values. Practically all internal stresses caused by rolling, drawing or forming are relieved during hardening.

Because of its conductivity beryllium copper is extensively used in such electrical applications as switches, relays, circuit breakers, fuse clips and brush holder springs. Also, because of its low mechanical hysteresis it is popular for springs used in measuring instruments, bellows and diaphragms.

Spring brass

Low cost

High conductivity

Good corrosion resistance

Comparatively poor mechanical properties and heat resistance

Spring brass (approx 70% copper, 30% zinc) has comparatively poor spring properties but is quite suitable for many noncritical applications. It is especially useful in low cost electrical applications where high temperatures or repeated flexing at high stresses are not encountered. The alloy suffers a sharp drop in mechanical properties above 150 F but is well suited for sub-zero applications.

Spring brass has an elastic limit of about 40,000 to 60,000 psi in bending and 25,000 psi in torsion. Maximum working stress is 40,000 psi. Its spring properties are obtained from the cold reduction of wire by drawing or strip by rolling. Spring brass cannot be hardened by heat treatment. It is not usually annealed since high annealing temperatures tend to destroy spring properties. After coiling or forming the alloy should be heated at a low temperature to relieve forming stresses and improve fatigue life and other mechanical properties. The alloy is readily electroplated, welded, brazed and soldered.

Other copper alloys

Good replacement materials for some applications

Easy formability

Good corrosion resistance

A number of other copper alloys are available as alternates for the three copper-base spring materials described above. In general, these alloys are characterized by easy formability and good corrosion resistance. However, their comparative cost, availability and specific mechanical properties should be checked against the characteristics of the more conventional copper alloys before final selection is made.

TABLE 5—PROPERTIES OF IMPORTANT COPPER SPRING ALLOYS

Type →	Phosphor Bronze A	Beryllium Copper	Spring Brass
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.32	0.297	0.309
Coef of Ther Exp, 10^6 per °F[a]	9.9	9.2	11.2
Elec Res, microhm-cm	9.58	8.31	6.6
Elec Cond, % IACS	18	22	26
Max Service Temp, F	225	225	150
MECHANICAL PROPERTIES			
Rockwell Hardness	B90-100	C35-42	B90
Mod of Elast in Tension, 10^6 psi	15	16	15
Temp Coef of Mod of Elast, per °F	-210×10^{-6}	-194×10^{-6}	-216×10^{-6}
Mod of Rigidity, 10^6 psi	6.25	6.7	5.5
Temp Coef of Mod of Rigidity, per °F	-220×10^{-6}	—	—
Tensile Strength, 1000 psi	100-150	160-200	100-130
Elastic Limit, 1000 psi			
Tension	60-110	100-150	75-80% ten str
Torsion	50-85	65-95	45-50% ten str

[a]Room temp.

Copper-manganese — This alloy (60% copper, 20% manganese, 20% nickel) can be precipitation hardened to give ultimate tensile strengths of 200,000 to 225,000 psi, a yield strength of 170,000 psi and a proportional limit of 120,000 psi. Its electrical conductivity is considerably lower than that of the three copper alloys described above, and it is not recommended for springs that must carry electrical current.

Cupro nickel—The presence of nickel in cupro nickel alloys (2.5 to 30% nickel, balance copper) provides a spring material with excellent corrosion resistance and moderately high tensile strength. Tensile strength of the spring tempered alloys ranges from 84,000 to 94,000 psi. Both electrical and thermal conductivity are fairly low. The cupro nickel alloys have good hot working properties, and their cold working properties range from good to excellent.

Nickel silver—The composition of nickel silver alloys varies widely. One of the most common spring alloys contains 56% copper, 25% zinc and 18% nickel. Tensile strength of this alloy ranges from 135,000 to 150,000 psi, with a Rockwell hardness of B95 to B100. The alloy has a better appearance than brass and is primarily used where a silver-white color is required, as in electrical and optical equipment. The alloy has good corrosion properties, but is not as corrosion resistant as some other copper-base spring materials.

Silicon bronze—This alloy (2-3% silicon, 1% manganese, balance copper), sometimes called spring bronze, can be used in many applications just as well as phosphor bronze. It is less expensive than phosphor bronze and its mechanical properties are slightly lower than those of Grade A phosphor bronze. Silicon bronze has a modulus of 15 x 10^6 psi in bending and 5 x 10^6 psi in torsion. It can be obtained in any wire size or flat stock thickness from 0.003 in. up. Stress relief treatment after forming is similar to that for phosphor bronze, since the material is cold drawn or rolled in a similar manner.

Aluminum bronze—Typical of the aluminum bronzes that can be cold drawn into spring wire is a 91 copper-7 aluminum-1% manganese alloy. This alloy has an ultimate tensile strength of 150,000 to 160,000 psi and can be used as a substitute for some of the more popular copper-base spring alloys. Its modulus of elasticity in tension is 16.5 x 10^6 psi, in torsion 6.3 x 10^6 psi. A similar alloy containing 3.5% aluminum and 1% silicon is also sometimes used for springs.

Tin brasses—Brass alloys containing 85-95% copper, 0.5-2% tin, balance zinc can be used as a substitute for phosphor bronze where high mechanical properties are not needed. These spring-grade brasses have slightly better properties than ordinary brasses, and they cost the same as other brasses with the same zinc content.

Cobalt alloy

(Elgiloy)

Good low and high temperature properties
High corrosion resistance

Despite its comparatively high cost, Elgiloy (40% cobalt, 20% chromium, 15% nickel, 7% molybdenum) is a popular spring material for specialized applications. In addition to being nonmagnetic, the alloy is suitable for use at sub-zero temperatures and up to 1000 F, provided torsional stresses are kept under 75,000 psi. At 1000 F, its relaxation or load loss is less than 5% in 48 hr. Although it is not normally considered as a constant modulus material it has good thermoelastic properties up to 600 F.

Elgiloy springs will deliver slightly more torque than comparable carbon springs when slightly stressed, and as much as 20% more torque when subjected to loads approaching yield strength. Maximum spring properties and corrosion resistance are obtained by heat treatment. It is the only corrosion resistant spring material that can be used interchangeably with carbon steel. Furthermore its resistance to both atmospheric and chemical corrosion is superior to that of the best stainless steels.

Elgiloy has a modulus of elasticity of 29.5 x 10^6 psi and a modulus of rigidity of about 12.3 x 10^6 psi at room temperature. Tensile strength (heat treated) is high—368,000 psi—and Rockwell hardness is roughly C59. Typical applications for the material are fountain pen nibs, watch springs, small gasoline engine valves, and various camera and instrument springs.

See next page for references

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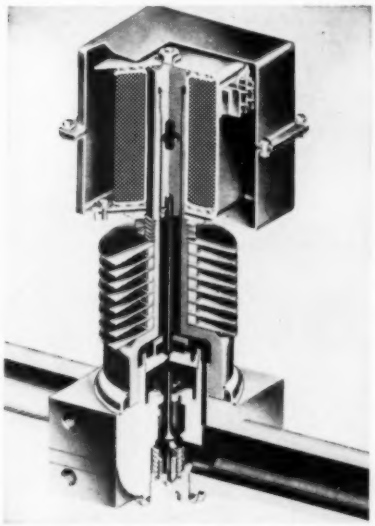
Nuclear Power Control

Convincing evidence of silicone insulation's inherent resistance to high temperatures is provided in this account of power valves for nuclear reactors from Automatic Switch Company, Florham Park, New Jersey.

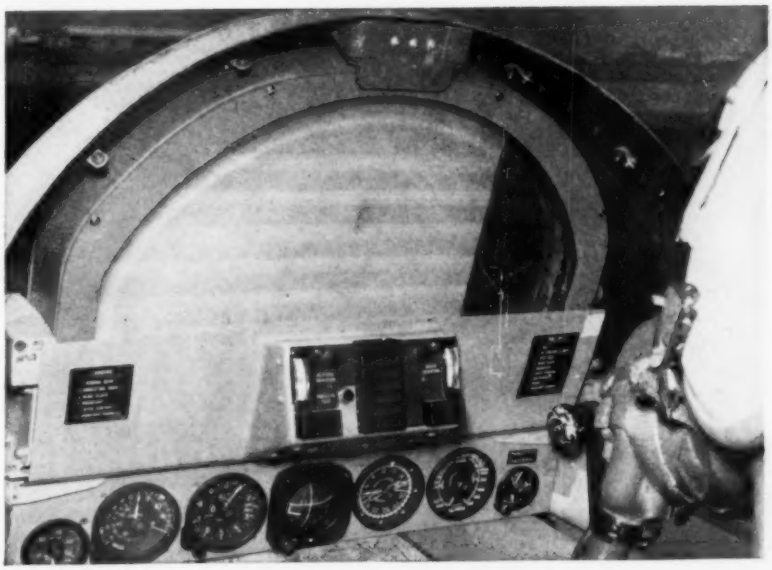
Asco is the world's largest manufacturer of solenoid valves especially designed for use with pressurized water reactors that power atomic submarines, surface vessels and power plants. The company has more than 100 valves now in service. Perfect-



ing them took countless hours of research and testing plus a practical solution to some extremely tough environmental design problems.

Exposed to radiation and the severe corrosive action of hot distilled water, the valves must be able to withstand continuous temperatures as high as 650 F and pressures up to 3,000 psi. Taking no chances on performance of the heart of the valve, Asco insulated all the coils of its nuclear valves and other high temperature solenoid valves with Dow Corning silicone insulation. Cooling fins on the valve body help dissipate some of the excessive heat. To date these coils have turned in an excellent record of performance.

The success record of the first atomic submarine underscores the reliability that can be achieved with silicone insulation and Asco's control valves. *No. 661*



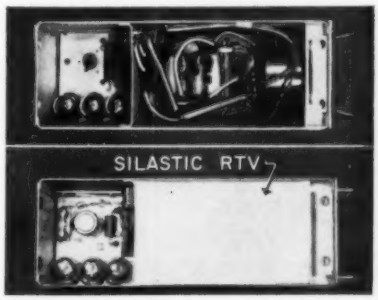
MORE EYES TO IMPROVE CONTROL EFFICIENCY

A unique pictorial display, designed to provide spacial orientation and navigational information, has been positively demonstrated and flight tested.

Kaiser Aircraft & Electronics, Palo Alto, California, in conjunction with Douglas Aircraft Company, Inc., has developed two new visualization units to be incorporated within an airplane cockpit. Designed to allow for more efficient aircraft control, these displays present information on TV tubes which provides the pilot with an artificial representation of the real world. This is accomplished by indicating, on a screen, the horizon and two reference areas representing the ground and the sky.

Flight tests with this new system in a Navy T2V aircraft have been conducted successfully by Douglas Aircraft Company, Inc. The electronically generated information is displayed on a Kaiser-Aiken transparent cathode-ray tube located in the windscreen of the aircraft. This thin transparent tube enables the pilot to see the information on the screen and at the same time to look through to the outside view.

The power supply, a conventional half-wave doubler circuit using a step-up transformer, provides a continuously variable voltage from zero to 15,000 volts. Kaiser engineers chose Silastic® RTV, the Dow Corning silicone rubber that vulcanizes at room temperature, as the potting material for the power supply unit. It effectively seals out moisture; retains ex-

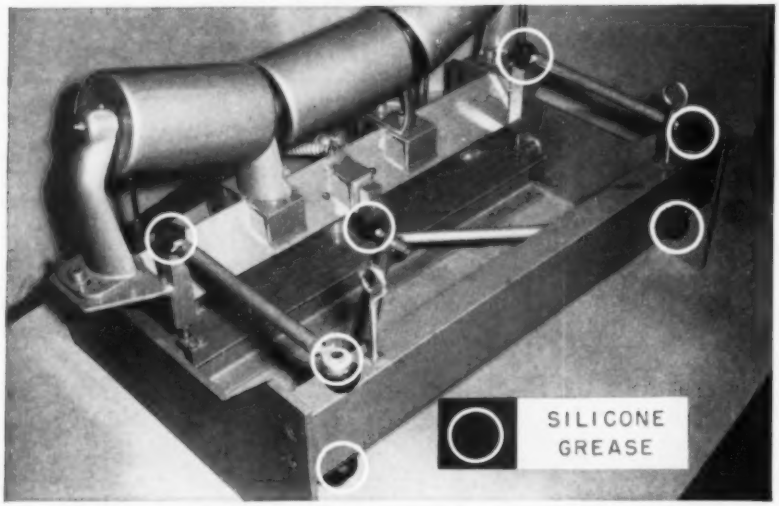


ceptional dielectric strength and dimensional stability from —55 to 250 C; and provides an easy means of potting. After mixing Silastic RTV with its catalyst, the mix is simply poured into the assembly, placed under vacuum to remove any trapped air bubbles, and allowed to vulcanize at room temperature.

Silastic RTV has eliminated the need of a troublesome oil bath. Expansion and contraction of oil over the wide (*Cont. pg. 2*)

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE



LUBRICANT ASSURES ACCURACY

The more critical the performance requirements of a new design, the greater the reason for specifying nongumming, oxidation-resistant silicone lubricants. Here, for example, is how Dow Corning 44 Grease contributes to the accuracy of continuous weighing equipment produced by Bell Electro-Way Division of Streeter-Amet Company.

The Electro-Way System automatically weighs material transported over a moving conveyor belt. A weighing platform containing a "floating" idler assembly is the heart of the unit. Passing loads deflect the idler downward. This deflection produces electrical weight-rate signals which are continuously integrated and digitally displayed as pounds and tons.

Free to move vertically, the idler is restricted in horizontal movement by three rod-end bearing assemblies which must remain in exact alignment at all times. Lubrication of the ball bearings is critical since any deterioration of the lubricant will alter the amount of deflection and adversely affect accuracy. What's more, climatic conditions that affect most lubricants vary considerably from one installation site to another.

Accuracy is assured by lubricating the ball bearings with a silicone lubricant, Dow Corning 44 Grease. This silicone grease provides long-lasting, uniform lubricity to meet most ordinary or severe operating conditions, both indoors and outdoors. According to Bell Electro-Way engineers, "44 Grease gives us dependability, durability and considerable freedom from maintenance."

Serviceable from —40 to 400 F, Dow Corning 44 Grease is nongumming, nonoxidizing — keeps equipment operating efficiently long after organic lubricants melt or oxidize. Durability and serviceability make 44 Grease ideal for many new designs. *No. 662*

SILASTIC RTV *(Continued)*

operating temperature span created a major packaging problem. Furthermore, arc-overs caused carbonization of the oil which encouraged further breakdowns.

For a convenient means of obtaining an effective, heat-stable seal that remains resilient and retains good dielectric properties, investigate Silastic RTV. Its unique combination of properties helps solve many design problems. *No. 663*

new literature and technical data on silicones

New Developments In Special Purpose Silicone Polymers is the title of a reprint from RUBBER AGE. Characteristic properties—heat stability, low temperature flexibility, solvent resistance, weathering and radiation resistance — are discussed. Comparison of phenyl and vinyl compositions, and tables on solvent resistance and low temperature properties of silicone rubber add to the value of this reference. *No. 664*

A Greaselike Transistor Potting Compound aids heat dissipation and protects from shock, vibration and moisture. Simply potting transistors with this silicone compound helps them give reliable service and meet even the most critical performance requirements. A six-page pamphlet details thermal stability, inertness, dielectric strength, and tabulates typical properties. *No. 665*

A Comprehensive Two-Part Article from ELECTRICAL MANUFACTURING on the techniques of cooling electronic equipment has been reprinted in a single, nineteen-page booklet. The first section contains methods and techniques of temperature measurement control, the second article shows practical methods for cooling specific electronic parts and systems. The text is well illustrated with charts, tables and sketches. *No. 666*

Designs on the Moon. Created specifically to meet the informational needs of rocket and missile designers, an illustrated brochure describes the finest in silicone materials — rigid, rubbery, fluid and dielectric. Whether you're concerned with nose cones, guidance frames, propulsion, or ground supports, your most rapid progress toward miniaturization, weight reduction, and reliable performance may result from specifying silicone products. *No. 667*

Syl-off Lets Go. Syl-off, Dow Corning silicone anti-adhesive coatings for paper and paperboard, provide engineers with a new design tool—controlled release. Lightweight, permanent, noncontaminating, nonmigrating Syl-off provides a nonoily slip surface that gives quick, easy release, avoids scratching and marring, reduces waste time and costs, and helps eliminate scrap. Paper and paperboard with Syl-off coatings warrant consideration as tools that may help solve design problems. *No. 668*

Dow Corning Corporation, Dept. 7020, Midland, Michigan

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FILE FACTS

ABS Resins and Methylstyrenes—Molded, Extruded

Type →		ABS Resins			Methylstyrene[b]	
		Medium–High Impact[a]	Extra–High Impact	Low Temp Impact	Polymethyl-styrene	Methylstyrene-Acrylonitrile
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.04–1.06	1.01–1.06	1.02	1.01–1.03	1.06
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.08–0.12	0.08–0.12	0.08–0.12	—	—
Coef of Ther Exp, 10^{-5} per °F	D696	4.7	4.7–5.6	4.7–5.6	—	—
Spec Ht, Btu/lb/°F		0.35–0.38	0.35–0.38	0.35–0.38	—	—
Refractive Index	D542	—	—	—	1.581	1.559
Transmittance (luminous), %		—	—	—	Transparent	Transparent
Water Absorption (24 hr), %	D570	0.2	0.3	0.2	0.05	0.31
Flammability, ipm	D635	1.3	1.3	1.3	Slow	Slow
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	2.6–2.9	2.1–2.6	1.0	—	—
Ten Str, 1000 psi	D638	4.5–8.5	5–8	3–4	6.6–8.9	9.3
Elong (in 2 in.), %	D638	5–100	20–50	30–200	2.2–5.0	2.5
Hardness (Rockwell)	D785	R85–118	R85–100	R30–65	M76–83	M83
Impact Str (Izod), ft-lb/in. notch	D256	0.5–6.0	5–9	6–10	0.33	0.40
Mod of Elast in Flex, 10^5 psi		37–45	—	—	4.0	4.6
Flex Str, 1000 psi	D790	7.5–11.0	6.8–8.0	3–4	10–13	16
Compr Str, 1000 psi	D695	—	—	—	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	$>8 \times 10^{13}$	1.8×10^{13}	$8.2–0.5 \times 10^{13}$	$2.6–5000 \times 10^{14}$	2.65×10^{11}
Dielec Str (short time), v/mil	D149	350–416	312	340–416	890–1950	610
Dielec Const						
60 Cycles	D150	2.7–4.2	2.7–4.76	2.7–4.0	—	—
10^6 Cycles	D150	2.8–3.6	3.78	2.8–4.1	2.48	2.81
Dissip Factor						
60 Cycles	D150	0.009–0.015	0.021	0.01	—	—
10^6 Cycles	D150	0.017–0.026	0.026	0.02	0.0006	0.0078
FABRICATING PROPERTIES						
Bulk Factor		2.25–2.27	2.29	2.27	—	—
Compression Molding						
Pressure, 1000 psi		>1	>1	>1	1–8	1–8
Temperature, F		325–375	325–375	325–375	300–375	300–375
Injection Molding						
Pressure, 1000 psi		6–30	6–30	6–30	10–30	10–30
Temperature, F		350–600	375–600	350–600	400–550	400–550
Mold Shrinkage, in./in.		0.001–0.010	0.001–0.010	0.001–0.010	0.0046	0.0035
HEAT RESISTANCE						
Max Rec Svc Temp, F		—	—	—	210	212
Heat Dist Temp (264 psi), F	D648	185–215	185	175–185	213–216	215
CHEMICAL RESISTANCE		Highly resistant to aqueous acids, alkalis, salts. Resistant to concentrated phosphoric and hydrochloric acids, alcohols, and animal, vegetable and mineral oils. Disintegrated by concentrated sulfuric and nitric acids. Soluble in esters, ketones, ethylene dichloride			Same as polystyrenes	Resists aliphatic hydrocarbons, gasoline, essential oils, vegetable and mineral oils
USES		Pipe, appliance housings and wheels, protective sportswear, housewares, howitzer cartridges			Radio cabinets, housewares and household utility parts, refrigerator parts, decorative lighting, packaging, electronic components	Same as polymethylstyrene. Also metering sight glasses, fan blades, combs, automotive interior parts, machine housings

[a] Range covers values obtainable in both Medium and High Impact grades.
[b] Recently withdrawn from commercial production.

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Edited by
John A. Mock

Titanium Tubing Has Good Strength, Fabricability

TENSILE PROPERTIES OF 3 Al-2.5 V TITANIUM TUBING

Condition	Ten Str, 1000 psi	Yld Str, (0.2%), 1000 psi	Elong (2 in.), %
COLD DRAWN (rm temp)			
Annealed	109	86	18
Half-Hard	126	98	12
Full-Hard	137	118	9
HEAT TREATED[a]			
Room Temp	132	120	11
600 F	96	74	8
800 F	89	68	11
1000 F	59	46	36

[a]Held ½ hr at 1700 F, water quenched; 6 hr at 900 F, air cooled.

COMPOSITION OF TITANIUM ALLOY (%)

Aluminum	2.0
Vanadium	2.7
Silicon	0.02
Iron	0.16
Manganese	0.01
Carbon	0.02
Nitrogen	0.015
Hydrogen	0.011

■ A new titanium tubing alloy, said to have tensile strength approaching that of stainless steel, but the workability of unalloyed titanium, has been developed by Superior Tube Co., Norristown, Pa.

The new alloy, called 3 Al-2.5 V titanium alloy (see composition table), was developed to "fill a need for a material that was as strong as stainless steel yet ductile enough to be cold drawn into small tubing." According to Superior, previously available alloys lacked sufficient ductility for cold working. The new alloy is said to be so ductile that it can be cold flared up to 35%.

Good yield strength

Annealed tubing made from the new alloy has a yield strength of 85,600 psi, as compared to 40,000 psi for unalloyed titanium tubing and 304 stainless steel tubing. In the full-hard drawn condition, the tubing has a yield strength of 118,000 psi, as compared to 85,000 for unalloyed titanium tubing and 140,000 for full-hard 304 stainless.

Fatigue properties of the new alloy are also said to be good. Annealed unnotched bar stock, for example, has an endurance strength of 45,000 psi when subjected to 100,000,000 cycles at room temperature.

According to Superior, the new tubing can be obtained in the ductile, annealed condition (for easy fabrication) and then heat treated for high strength. The company guarantees a minimum heat-treated yield strength of 100,000 psi and a minimum tensile strength of 75,000 psi. Typical room and elevated temperature tensile properties are given in the accompanying table.

The tubing, available from 0.012 to 1.125 in. o.d., is recommended for aircraft and missile parts requiring an increased strength-weight ratio, and in process equipment where high strength, as well as corrosion resistance, is required.

Here is the first report on

Properties of Ethylene-Propylene Copolymer

■ Technical data are now available on a relatively new synthetic rubber. The new rubber—a copolymer of propylene and ethylene—was actually introduced a little over a year ago (see M/DE, July '58, p 4) but has not been available until now. According to Montecatini, Co., Milan, Italy, the material is available on a semi-commercial basis from Chemore Corp., 21 West St., New York 6.

Properties

The new material, called C 23, is described as a very-high-molecular-weight copolymer with low specific gravity (0.85). It can be processed on standard equipment

and can be easily mixed with standard fillers. According to Montecatini, the rubber's low specific gravity reduces the cost of finished products because it provides more product per unit weight.

The mechanical properties of the new ethylene-propylene copolymer are similar to those of natural (NR) and butadiene styrene (SBR) rubbers. In addition, the material has good low temperature properties, good electrical insulating characteristics and good wear resistance. It is also said to have excellent resistance to outdoor aging, sunlight, ozone, heat, acids, alkalis and hydraulic fluids, and, except for flame resistance, compares favorably with Hypalon rubber (see table).

RESISTANCE TO VARIOUS ENVIRONMENTS

Environment ↓	C 23	Hypalon	SBR
Outdoor Aging	E[a]	E	G
Sunlight	E	E	A
Ozone	E	E	P
Heat	VG	VG	A
Flame	VP	E	VP
Alkalis	E	E	VP
Acids	E	E	G
Solvents			
Aliphatic Hyd	P	VG	P
Aromatic Hyd	VP	P	VP
Chlor Solvents	VP	P	VP
Hydraulic Fluids	E	E	E

[a]E = excellent, VG = very good, G = good, A = average, P = poor, VP = very poor.

PROPERTIES OF RUBBERS COMPARED

Property ↓	C 23	Natural	SBR
PHYSICAL PROPERTIES			
Spec Grav	0.85	0.93	0.47
Spec Ht, Btu/lb/°F	0.52	0.45	0.47
Ther Cond, Btu/hr/sq ft/°F/ft	0.21	0.11	0.13
Coef of Ther Exp, per °F	10^{-4}	0.93×10^{-4}	10^{-4}
MECHANICAL PROPERTIES[a]			
Ten Str, psi	3800-4000	4100-4400	3700-3900
Elong, %	450-500	550-600	400-450
Hardness (Shore A)	60-65	65	67
ELECTRICAL PROPERTIES			
Vol Res, ohm-cm	10^{16}	10^{15}	10^{15}
Dielec Str, v/mil	700	500	600
Dielec Const, (1 kc)	2.2	2.6	2.9

[a]Reinforced with 50 parts carbon black.

How it's made

The ethylene-propylene copolymer is made by polymerizing alpha-olefin polymers with stereospecific catalysts developed by Professor Guilio Natta of Milan Polytechnic Institute. Alpha-olefin polymers have a sterically regular structure within the macromolecule. Their main linear head-to-tail chains contain long sequences of tertiary carbon atoms with the same steric configuration. The stereospecific catalysts selectively direct polymerization toward the production of isotactic, high molecular weight materials.

Development of this copolymer is the second major commercial result of Professor Natta's work on directed catalysis. The first was the discovery of isotactic polypropylene plastic (see M/DE, Jan '58, p 110).

According to Montecatini, the new synthetic rubber is expected to be competitive with natural and other synthetic rubbers. Potential uses for the rubber include tires, conveyor belts, gaskets, packings and other mechanical goods.

Improved Metallic Coatings by Vacuum, Vapor Plating

■ Two new advances have been made in the fight against corrosion: 1) a new process for vacuum metallizing a relatively *thick* skin of aluminum on steel and other metals, and 2) an improved vapor plating process for depositing chromium, molybdenum and tungsten on metallic and nonmetallic shapes.

New metallizing process

Thick aluminum coatings—The new aluminum vacuum metallizing process, developed by National Research Corp., Cambridge, Mass., is similar to the vacuum metallizing technique now used to put a bright (but merely decorative) finish on mirrors, plastic toys, etc. In vacuum metallizing, aluminum is "boiled" in a vacuum and the aluminum vapor condensed on the part to be coated. Until now, this technique has only produced coatings a little more than one-millionth of an inch thick. According to NRC, the new method produces a pure aluminum coating up to 0.004 in. thick. The coating is tightly adherent, ductile and nonporous; easily anodized and dyed; and equally successful on such diverse metals as high tensile and mild steels, aluminum die castings and forgings, cast iron, titanium and magnesium.

Applications — Although the new coating process is still in the pilot plant and developmental stage, NRC feels that it will ultimately find application in the automotive, aircraft and appliance industries. In the automotive industry, the thick aluminum coating could be used 1) as an alternative to dipping body sheet steel in molten aluminum; 2) to provide corrosion protection for aluminum die castings and forgings; and 3) as a protective coating for inexpensive stamped or pressed steel parts. Because the thick aluminum coating provides better protection at about the same cost, it might also replace chromium plating for bumpers and trim.

In the aircraft industry, the thick aluminum coating could

prove valuable for protection of high strength steel fasteners, fittings and structural members against corrosion from atmospheric attack, fuels, grease, oils, salt spray, etc. These parts are currently protected by either plating or dipping in molten aluminum. Both of these present methods have drawbacks: electroplating tends to cause hydrogen embrittlement, and aluminum dipping causes loss of tensile strength (as a result of the high temperatures) and the formation of a brittle iron-aluminum alloy.

The process—Thus far, no details have been revealed on how NRC achieves the thick aluminum coatings. The only information available is that "licensing arrangements are being discussed with a number of leading companies in several fields."

Improved vapor plating

Development of improved chemical compounds of chromium, molybdenum and tungsten, as well as some undisclosed modifications in technique, have resulted in what is said to be a substantial improvement in the traditional vapor plating (gas plating) process.

According to Alloyd Research Corp., 202 Arsenal St., Watertown, Mass., the improved process is basically the same as the conventional one—chemical reaction (either reduction or decomposition) of a volatile compound of chromium, molybdenum or tungsten at a heated surface. However, superior coatings depend upon several factors: temperature, flow rate of the gas stream, pressure, precleaning, and compound concentration. In fact, conditions are so critical that a slight change in a process variable can result in a metal powder, a dendritic structure, or a porous and nonadherent coating. According to Alloyd, the new process maintains strict control over these variables.

Chromium and molybdenum coatings *are applied to inner surfaces of copper tubing.*

Metallizing chamber *for producing thick aluminum coatings.*

Advantages — Alloyd says the improved vapor plating process offers several advantages over chromium electroplating: coatings are nonporous, they are ductile, and they are not subject to hydrogen embrittlement. Other characteristics: 1) coatings are deposited with uniform thickness; 2) they can be used at temperatures well over 300 F; 3) they can be used on metals as well as such nonmetallics as glass, ceramics and graphite; and 4) they can be used on complex shapes such as the insides of tubes (see accompanying photo).

Results of two tests were cited as proof of the superior quality of the coatings:

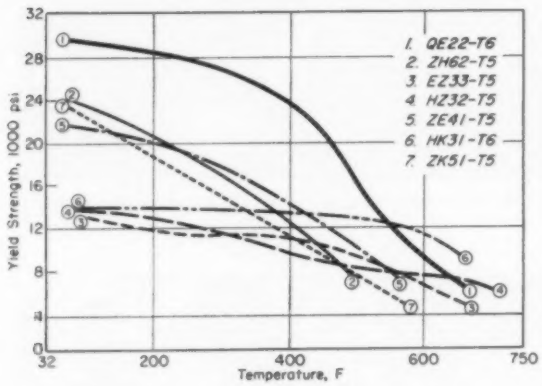
1. Chromium coatings up to 0.005 in. thick on copper and steel showed no signs of cracking, spalling or flaking after extensive deformation in qualitative bend tests.

2. Chromium-coated copper showed no signs of corrosion after being immersed 64 hr in 20% nitric acid.

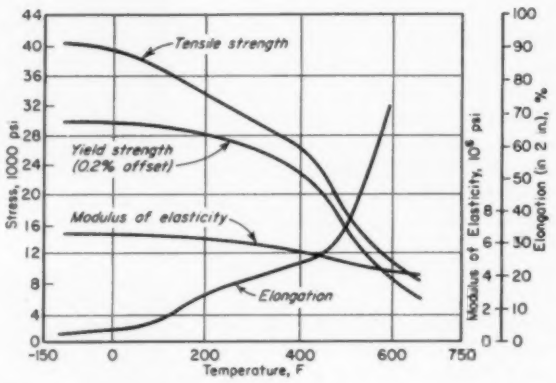
Applications — Vapor plated chromium, used as a protective cladding against corrosion, may provide a low cost substitute for stainless steel in valves, tubing and other equipment used in the chemical, dairy and food industries. Another potential application is the use of vapor plated high purity, high density tungsten to prevent contaminants in the base metals of certain electronic components from adverse-

ly affecting electronic emission characteristics. The use of heavy coatings of molybdenum and tungsten on graphite for missiles and rocket nozzles is another possibility.

Although Alloyd is ready to negotiate with various companies in the automotive and aircraft industries, it points out that the process is still in the developmental stage.



***Yield strength** of QE22-T6 magnesium alloy compared to that of six other magnesium alloys.*



***Effect of temperature** on tensile properties of heat treated QE22-T6 magnesium alloy.*

Three Magnesium Alloys for High Temperatures

■ Three new magnesium alloys have been developed for elevated temperature service. One of the alloys, developed by Dow Chemical Co., Midland, Mich., is said to be the first die casting alloy suitable for service above 500 F. The second, also Dow's, is said to have excellent tensile strength at temperatures above 600 F. And the third, developed by Magnesium Elektron Inc., 630 5th Ave., New York 20, is said to have the highest yield strength of any cast magnesium alloy.

Dow's alloys

HM11XA — This die casting alloy, a member of the magnesium-thorium group (composition: 1% thorium, 1% manganese), is said to have a tensile

(continued on p 136)

MECHANICAL PROPERTIES OF EK31XA

Property ↓	Typical	Guaranteed
Ten Str, 1000 psi...	35	31
Yld Str, 1000 psi...	22	19
Elong, %.....	4.5	2.5
Shear Str, 1000 psi.	23	—
Brinell Hardness...	64	—

TENSILE PROPERTIES OF HM11XA CASTINGS

Temperature ↓	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation (in 2 in.), %	Modulus of Elasticity, 10^6 psi
Room Temperature.....	30	21	4	7
400 F.....	17	15	14	6
600 F.....	12	11	14	6
800 F.....	8	7	15	5

MORE WHAT'S NEW IN MATERIALS

Steel strip rolled from powder 136
Forging superalloys 148
Rubber-coated fibre makes tough gasket ... 152
Glass peening cleans metals without damage 154
PVA synthetic fibers..... 154
Glass-rubber tape heats without wires ... 156
Straight brass rod for screw machines 156
Color of plastics is accurately controlled .. 158
Magnesia ceramic withstands 4300 F 160
Phosphorescent paints are self-luminous 160
Columbium alloys strong at 2000 F 162
Nickel-base alloy resists fluoride salts 164
New silane improves plastics laminates 168
3200 F refractory handles like plastic 172
Ductile iron 172
Other news 174

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No. 4 of a series

Eastman 910 Adhesive solves another production bottleneck

The L. G. Balfour Company, of Attleboro, Mass., manufactures trophies, award placques and fraternal jewelry.

Methods of assembling a wide variety of materials quickly and simply are of prime concern in the manufacture of such products.

Balfour has found an answer in quick-setting, high-strength Eastman 910 Adhesive.

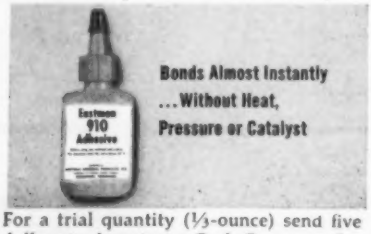
With this new adhesive, Balfour obtains virtually instantaneous bonds... eliminates soldering on many items... cuts up to 15 hours' processing time to speed delivery of rush orders.

As for strength, a medallion secured to an onyx base with one drop of adhesive *could not be removed without pulling away some of the onyx itself.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?



For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9108 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. E-8, Kingsport, Tenn.

For more information, circle No. 372

What's new IN MATERIALS

strength of 7800 psi at 800 F and is presently being evaluated for missile and aircraft applications. Tensile properties of die cast HM11XA at room and elevated temperature are given in the accompanying table.

In addition to elevated temperature strength, Dow lists the following advantages: 1) good damping capacity (superior to conventional aluminum and magnesium-base die casting alloys); 2) good thermal conductivity (equivalent to conventional aluminum-base die casting alloys and superior to AZ91, the standard magnesium die casting alloy); 3) ease of die casting with standard equipment; 4) higher modulus of elasticity at elevated temperature than AZ91; and 5) ability to be finished with nearly all currently used finishes.

According to Dow, cost of HM-11XA die castings is "higher than that of AZ91 castings."

EK31XA—This new magnesium-rare earth sand casting alloy (composition: 3.2% didymium, 0.6% zirconium) was developed for missile and rocket applications, and is said to combine good room temperature tensile properties with excellent tensile strength at temperatures up to 600 F. In addition, sand castings are said to exhibit excellent creep resistance at 600 F for times up to 10 hr. At temperatures up to about 450 F, sand castings exhibit good creep strength for 1000 hr.

Typical and guaranteed tensile properties are given in an accompanying table.

Magnesium Elektron's alloy

MSR alloy (ASTM QE22-T6) is described as a fully heat treatable alloy "based on the magnesium-rare earth-silver-zirconium system." Composition is 2.5% silver, 2.0% fractionated rare earth metals and 0.7% zirconium.

According to Magnesium Elektron, the alloy has the highest yield strength from 0 to 500 F of any cast magnesium alloy (see accompanying graph). Other characteristics claimed for the new alloy include: 1) adequate tensile strength and ductility at room temperature; 2) good tensile properties at elevated temperatures (see accompanying graph); 3) good short-time creep properties (at 400 F, QE22 is said to have higher short-time creep strength than any other magnesium casting alloy); 4) good long-time creep properties (equivalent to EZ33A); 5) good fatigue properties (better than any other magnesium casting alloy); 6) stability at elevated temperatures; 7) resistance to stress corrosion; 8) ease of casting; and 9) ease of welding.

Steel Strip Rolled from Powder

Pour iron powder into a hopper at at one end—coil up steel strip at the other end. This is the kind of continuous strip mill that Republic Steel Corp. expects to have in five to six years.

As announced last month (M/DE, July '59, p 3), 2-in. strip is now being rolled in Republic's new Research Center. As of mid-June, about 1800 lb of strip had been produced. The company says it will soon be ready to set up a pilot plant to produce wider strip (about 12 in.) and to solve many of the problems that will arise in commercial production of strip 48 or 50 in. wide.

New strip similar to conventional material

At present, Republic is concentrating on low carbon steel strip (0.05-0.10% C), which is the backbone of the sheet and strip business. But the process is adaptable to higher carbon and alloy steels as well.

According to Peter Robertson, Republic's vice president for research and planning, the new strip has the same metallurgical structure as conventional strip. Photomicrographs that have been displayed bear out this contention.

As for mechanical properties, Robertson says the strip meets the "standard property specifications" for steel of the same carbon content. More important, perhaps, is the fact that the strip passes a stringent formability test (similar to a GM test), indicating its suitability for stampings (see photo on p 138).

Main advantage is lower capital cost

Although the process should require less than 60% of the capital investment needed for conventional

New "washing machine" makes CLEAN stainless steel

More often than not, titanium-bearing stainless can hike your fabrication costs . . . due to subsurface stringers or banding that cause excessive scrapping of parts. At Eastern, however, these harmful inclusions come out in the "wash."

Eastern's exclusive slag wash melting process produces the *cleanest* titanium-bearing stainless you can buy . . . exceptionally free from non-metallic contaminants . . . and at *no extra cost*. Eastern's new high-capacity slag furnace will meet industry's growing demand for such titanium-bearing steels as 321SW, 19-9DL, A-286, 19-9DX. Which do *you* need—and how fast?

EASTERN STAINLESS STEEL
Baltimore 3, Maryland, U. S. A.

For more information, turn to Reader Service card, circle No. 410

Bunting makes the "almost impossible" bearings and parts

The photograph shows a sintered bronze bearing used in an exceedingly popular home laundry drier. It offers several unusual features, some of which you may find useful in designs you are considering as sintered parts. In the first place because the splines on the O.D. of the bearing abut the back of the bearing flange, this is a part which would be almost impossible to produce by machining but can readily be produced by powder metallurgy.

Second, the splines do not extend the full length of the bearing but the density of the splines must be the same as the remainder of the bearing. This requires intricate and unusual tooling and understanding of the problem which is one of the reasons why this manufacturer put his design in the hands of Bunting.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze, sintered metals or Alcoa aluminum, see Bunting first.

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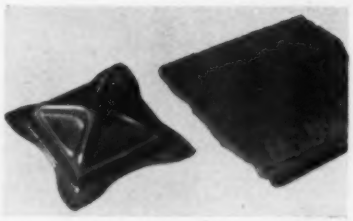

***Formability** of experimental steel strip is indicated by stamped piece at left. Portion of green strip is shown at right.*

strip, and operating costs should be at least competitive with present costs, no reduction in the cost of strip should be anticipated by users. As is the case with other new steelmaking processes now being explored or used, the main impetus behind the new process is the desire to reduce the amount of capital investment needed for plant expansion. Such costs have undergone tremendous increases—on the order of four or five fold—in the past 20 years.

Rolling from powder is only one of many approaches to reducing the capital cost of steel expansion. Up to now major attention has been focused on the oxygen conversion process, already widely accepted. The powder process—by-passing the melting step completely—presents the most radical departure from conventional steelmaking processes. There is no need for coke ovens, blast furnaces, open hearths, soaking pits or blooming mills.

Preview of the Republic process

The continuous process planned by Republic will consist essentially of the following steps:

1. Iron ore is highly purified and reduced to metallic iron powder. Carbon content is adjusted to the desired level.

2. The powder is funneled between two rolls where it is compressed into a "green" strip having enough strength to keep it intact until the next processing steps. Edges

Considerable help was provided by Henry H. Hausner, Consultant, New York City, who was instrumental in arousing interest in the process in this country and who made available his personal files. Also very helpful were D. K. Pickens, Earle C. Smith, A. I. Nussbaum, of Loma Machine Mfg. Co., and Arthur Folken, of Stanat Mfg. Co.

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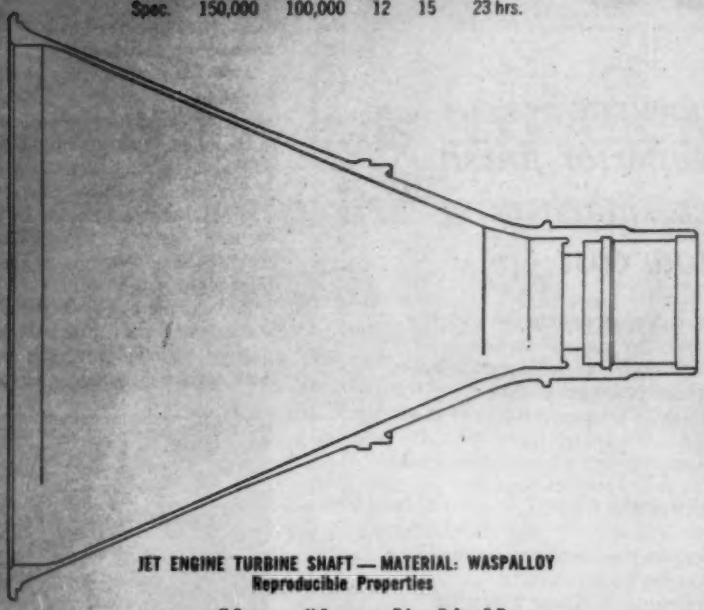
All this, of course, gives our customers a better component functionally and economically. Check the accompanying comparison of the specification values and obtained values on the two jet turbine rotating components shown—let us show you what we can do with your problem forgings—just CALL, WRITE, or COME BY

JET ENGINE TURBINE DISC — MATERIAL: INCO 901

	T.S.	Y.S. .2%	E.L.	R.A.	S.R. 1200° F. 80,000 lb./sq. in.
	175,000	128,000	20	23	225 hrs.
Spec.	150,000	100,000	12	15	23 hrs.



JET ENGINE TURBINE SHAFT — MATERIAL: WASPALLOY
Reproducible Properties

	T.S.	Y.S. .02%	E.L.	R.A.	S.R. 1350° F. 70,000 lb./sq. in.
	196,200	131,700	23	32	71 hrs.
Spec.	160,000	90,000	15	18	23 hrs.

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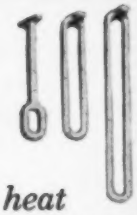

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of the strip are formed simultaneously by two additional disk rolls.

3. The green strip passes through a furnace where it is sintered at 2000 F or higher (as high as 2200 F) in a reducing atmosphere.

4. The sintered strip passes through a hot strip rolling stand where it is reduced to about 95% of theoretical density. Because of the large surface area provided by the grains of powder, Republic engineers say it will probably be necessary to use a protective atmosphere through this stage of the process.

5. The strip passes through two more hot rolling stands and is coiled. The first of these stands compacts the strip to virtually 100% of theoretical density; the second reduces it to the desired gage.

6. These hot rolled coils—identical with conventionally produced ones, it is claimed—then go through the usual operations of pickling, cold rolling and annealing before being re-coiled or cut into sheets.

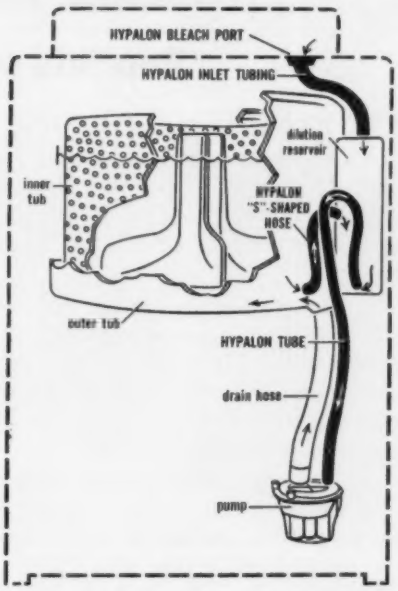
Some key problems— and some solutions

This bare outline, as sketched by Republic, gives little indication of some of the complex decisions still to be made. Further discussion with Earle C. Smith, Republic's director of research, indicates that:

1. Much work remains to be done on mill design — particularly roll bearing design—before a continuous pilot plant will be built.

2. The method of introducing carbon is not yet set. The various alternatives include controlled reduction with carbon monoxide, and controlled

***Powder is funneled** to a set of four rolls. Compacted strip is then sintered and hot rolled.*



MAYTAG TIMED BLEACH INJECTOR. Concentrated chlorine-type bleach is poured through the bleach port into the dilution reservoir. Here it is diluted four times by water from the tub. Diluted bleach is metered to the pump, and then delivered to the washer's outer tub. Within four minutes after the wash cycle begins, bleach reaches optimum concentration in the tub.

Maytag finds HYPALON® immune to chlorine bleach at 158° F.

Maytag had a good idea for their All-Fabric automatic washer. Why not design a timed bleach injector to automatically dilute and meter liquid bleach into the wash water? Then the housewife would have to add bleach only once . . . when she loaded the machine. Bleaching would be safe for fabrics, and wouldn't destroy the optical brighteners in detergents.

But there was a problem. To do this, they'd need flexible hose and tubing that could safely handle chlorine-type liquid bleaches. Maytag engineers tested hoses of several materials in 5¼% hypochlorite solution at 158° F. All hoses except one suffered damage within 24 hours. The exception: a hose made of HYPALON, a Du Pont synthetic rubber. It remained unharmed even after a week's testing.

HYPALON was the solution—just as it has been for numerous other appliance design problems. For example, drain hose coated with HYPALON has proved to be color stable and impervious to ozone. On hermetically sealed compressors, HYPALON jacketing for lead-in wire has resisted temperatures to 350° F. To see how HYPALON can serve you, just write for a copy of our booklet outlining properties and performance. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MM-8, Wilmington 98, Delaware.

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mixing of pure and higher carbon powders.

3. Sintering temperatures may come down. Fast sintering is essential to a continuous hot rolling process; hence the high temperatures used in the Republic process. But with heavier mills and other improvements it may be possible to get the sintering temperature down below 2000 F—perhaps even as low as 1800 F.

Powder rolling is not new

There's "nothing new," was the offhand reaction to Republic's recent announcement from men in the powder metallurgy field. And it is true that the process does not differ in principle from powder rolling processes already operating on a pilot scale in this country. What differences there are appear to lie in the material—most previous work has been on nonferrous metals and stainless steel—and in mechanical details (for example, the four-roll compacting mill).

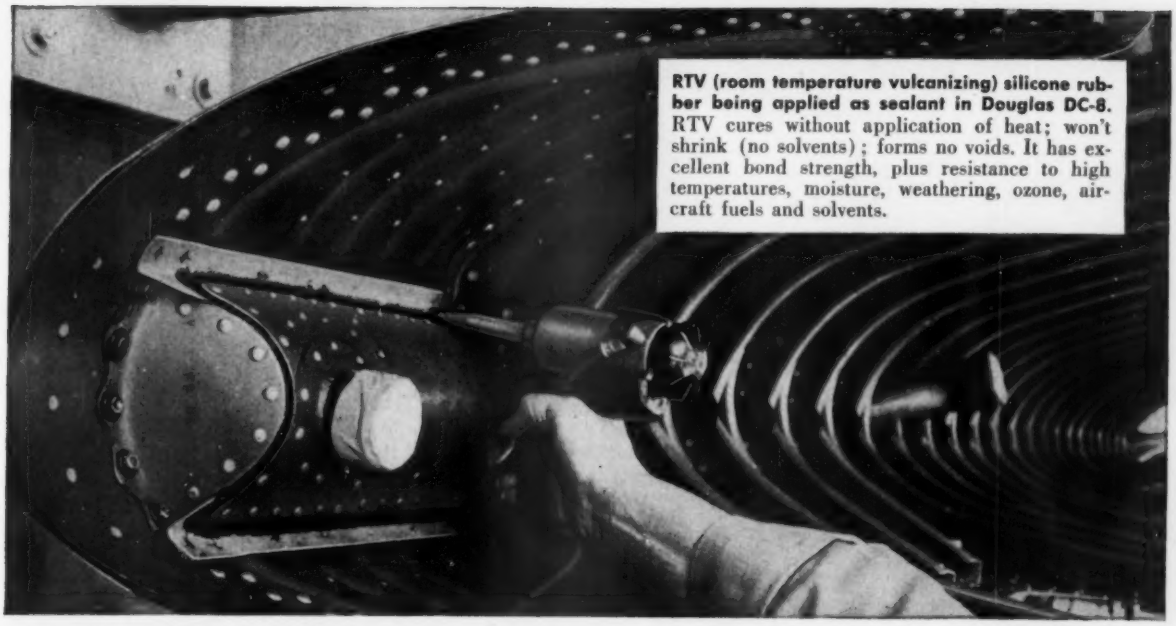
The idea of powder rolling is at least 57 years old; it was mentioned in a German patent in 1902. Various methods have been described since then in a number of U. S. patents. However, it was the German work during and after World War II that led directly to the first applications of continuous powder rolling in this country.

In 1951, the comprehensive work done by Naeser and Zirm of Mannesmannwerke in Germany became known here. Originally, the sintered strip was cold rolled and intermediately annealed—a technique more suited to batch processing than to continuous production. Also, it seemed that the carbon content might best be achieved by gas carburizing the thin sintered strip.

First U. S. continuous line rolls copper

While development continued in Germany, the process came to the United States, where development proceeded along two separate lines—nuclear and commercial.

As a result of discussions between Henry H. Hausner and Dr. Naeser, Sylvania Electric Products, Inc. began to study powder rolling under an AEC contract. The Sylvania work, supervised by Samuel Storchheim



RTV (room temperature vulcanizing) silicone rubber being applied as sealant in Douglas DC-8. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

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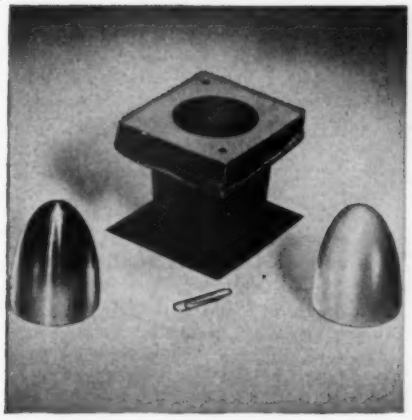

Prototype jet engine nose cone (right) cast in RTV mold. Epoxy parts cast in flexible RTV molds have a bright, glossy surface and reproduce extremely fine detail. No parting agent is required for even the most complex parts. High tensile and tear strength is retained even after prolonged heat aging.

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gal-va-nize (gal/və nīz'), *v.t.* 1. to stimulate by or as by a galvanic current. 2. to coat (metal, esp. iron or steel) with zinc.

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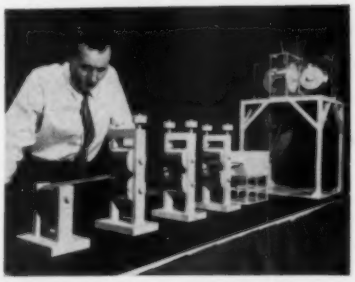


***Model** of process for rolling steel strip from iron powder.*

and at first confined to 18-8 stainless, showed that "the new method of fabricating strip seems applicable to both soft and moderately hard metal powders." The process offered special advantages for metals used in nuclear equipment because many of them must first be obtained anyway in the form of powder, made by reducing purified chemical compounds.

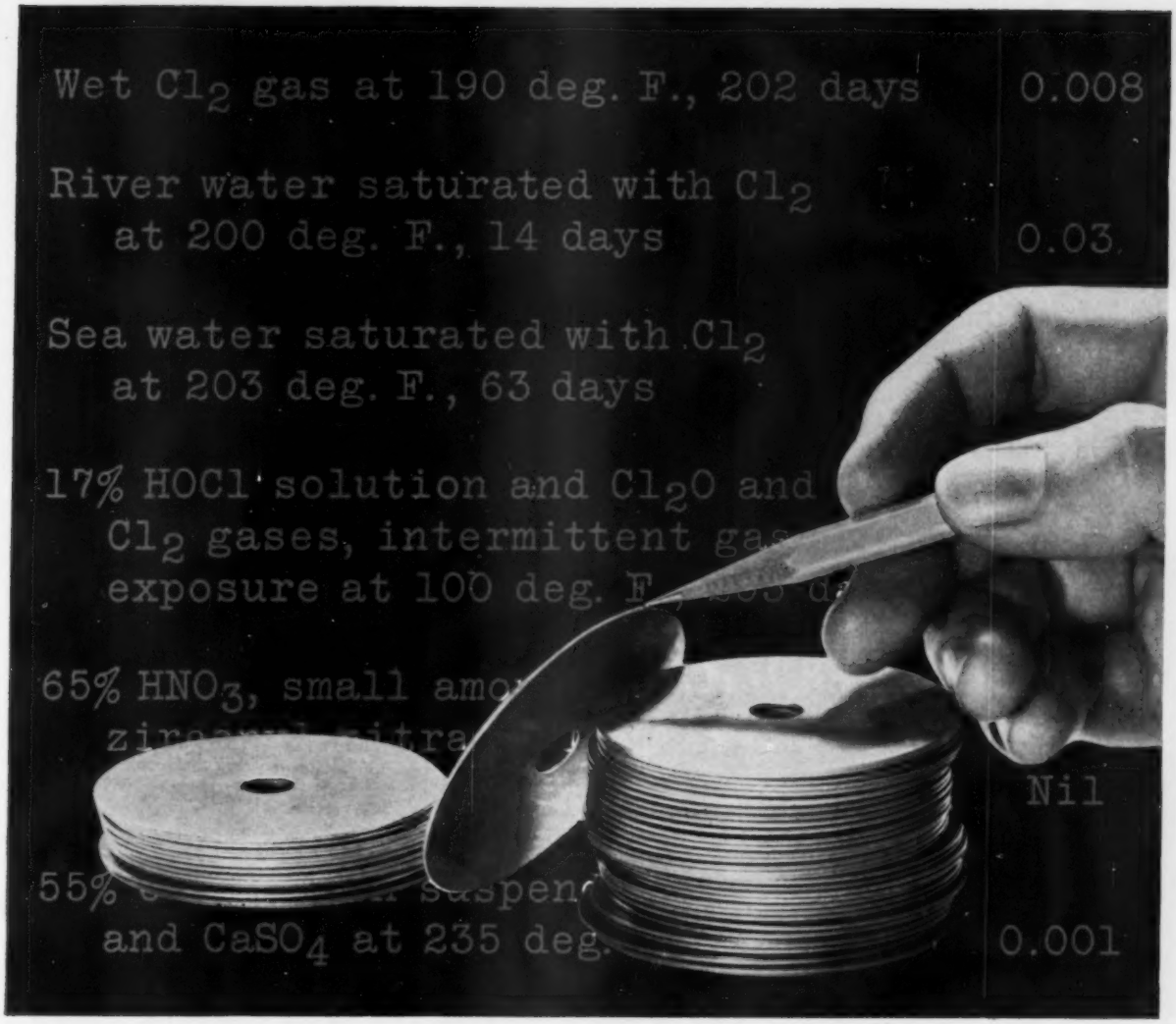
Meanwhile, Chemetals Corp., of New York City, obtained an exclusive license from Mannesmann Akt. and Sundwiger Messingwerk to use the German process for nonferrous powders.

Previously, Chemetals had developed a hydrometallurgical process for producing a pure, inexpensive copper powder from scrap. The first commercial installation was at Whitaker Metals Corp. in North Kansas City, Mo. The question was: what to do with large quantities of copper powder—quantities that could not be absorbed by the present demands of powder metallurgy. The answer was to try to roll the powder into strip.

And so Chemetals Corp., with its powder rolling license, entered the picture again. A pilot program was set up by E. W. Bliss Co., Salem, Ohio with the assistance of S-K-C Associates, consultants of Paterson, N. J. At present, Bliss can roll up to about 200 lb per hr. Strip 0.0106 in. thick is reported to have 40,000 psi tensile strength, 34% elongation and 101% IACS electrical conductivity.

The economics of this process are very attractive. The copper powder in quantity production will cost about the same as electrolytic copper. Assuming a production level of about

TITANIUM... COMING OF AGE!


Wet Cl_2 gas at 190 deg. F., 202 days
0.008
River water saturated with Cl_2
at 200 deg. F., 14 days
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Sea water saturated with Cl_2
at 203 deg. F., 63 days
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TORCH TEST OF MOLYBDENUM AT 3400° F

W-2 CHROMALLIZED specimen, left, completely resists oxidation. At right, volatile oxide vapors are given off by untreated piece as it burns away.

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Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

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For more information, turn to Reader Service card, circle No. 369

What's new IN MATERIALS

50 tons per day and a common commercial-size strip (0.030 in. thick, 18 in. wide), the cost of converting ingot to strip is about 8¢ per lb—the average cost of converting powder to strip about 2¢ per lb. These figures, furnished by D. K. Pickens, president, Chemetals Corp., indicate a savings of 6¢ per lb. For thinner gages, the saving is even greater.

More graphically, Pickens says, this cost differential may be illustrated by the difference between a powder rolling installation in a building 100 ft long and in a conventional plant which may be as long as 1200 ft.

It was during this period of development a few years ago that the advantages of hot rolling, rather than cold rolling, became increasingly obvious. The Bliss-Chemetals setup uses cold compacting and hot rolling. As S-K-C pointed out at the 1957 MPA meeting, hot rolling offers greater consolidation per pass and leaves the strip in the annealed condition, thus reducing the number of passes and anneals necessary and consequently the amount of equipment needed. Furthermore, some materials, notably aluminum, *must* be hot rolled.

Strip from powder has other advantages

Although Republic's main interest is in reducing future plant investment costs, developers of continuous powder rolling have cited many other advantages. The early German interest was primarily in obtaining sheets of materials that are hard to shape, such as the refractory metals. Some later objectives:

1. *Random crystal orientation.* Because of the limited amount of working, directionality is not marked. It is possible that sheet materials particularly suitable for deep drawing can be developed. Such materials would have less tendency to "ear" than conventional metal strip.
2. *Finer grain size.* Cold compacting as opposed to hot pressing, for example, reduces the opportunity for excessive grain growth.
3. *Greater purity.* Some metals used in nuclear equipment require high purity and can only be produced from pure metal powders.
4. *Producing bimetals.* A strip can be clad on one or both sides by

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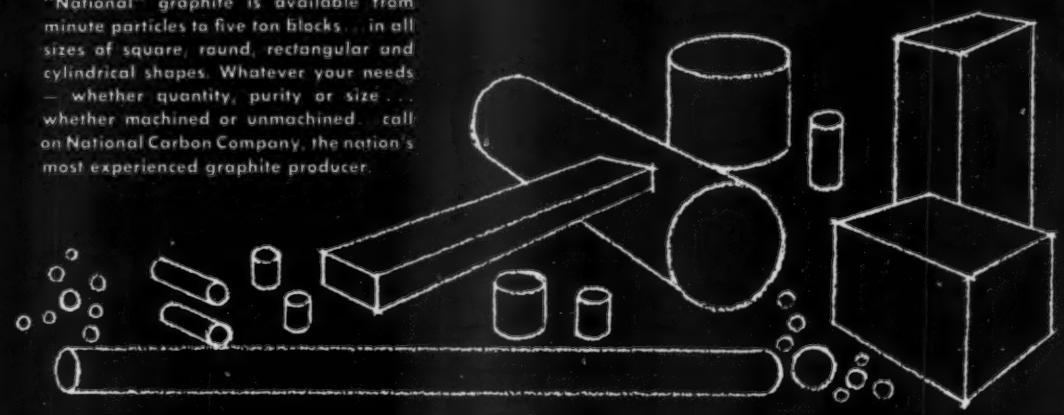
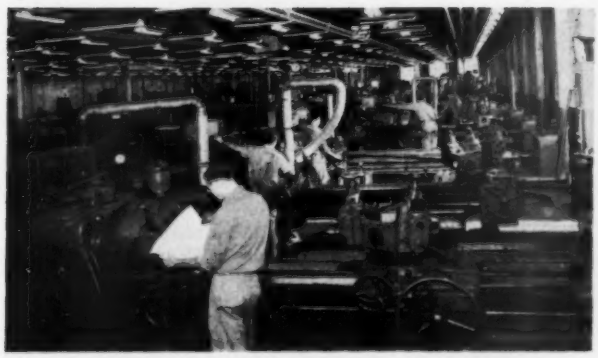


...and NATIONAL CARBON can machine it to your specifications



One of several well equipped NATIONAL CARBON machine shops for fabricating graphite.

Economically machining graphite at National Carbon Company is a result of years of graphite machining experience teamed with modern equipment located at several strategic locations. Turning out simple or intricate shapes and holding to close tolerances are everyday procedures at these shops. No job is too small or too big, too simple or too complex to receive the required expert consideration and attention.

Whatever your needs, whether simple or complicated parts made from standard or special grades, let National Carbon Company quote on your requirements. For details, contact your National Carbon representative or the nearest sales office.

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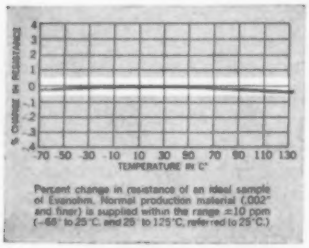

Percent change in resistance of an ideal sample of Evanohm. Normal production material (.002" and finer) is supplied within the range ±10 ppm (−65° to 25°C. and 25° to 125°C. referred to 25°C.)

Wherever exceptional stability over a wide temperature range is essential, EVANOHM is the accepted standard of performance. This high-reliability resistance alloy provides high specific resistance, low temperature coefficient, low thermal EMF to copper. EVANOHM is especially recommended for use in resistors, aircraft instruments, for guided missiles, rockets and other precision equipment. Available in bare wire, enamel, formvar, polyurethane, silk, cotton, nylon and glass insulation. Write for complete electrical and mechanical data and recommendations on your specific application.

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For more information, turn to Reader Service card, circle No. 406

using it to carry powders through he rolls. This method has been used at the brass works of Sundwiger in Hemer-Sundwig in Germany. This pilot plant uses powder rolling to produce copper, phosphor bronze, cupro nickel and various bearing alloys.

5. *Less expensive foil.* In general, the cost advantages of powder rolling are greater for materials that work harden rapidly. Especially for such materials, powder rolling should offer considerable economies in producing thin foil.

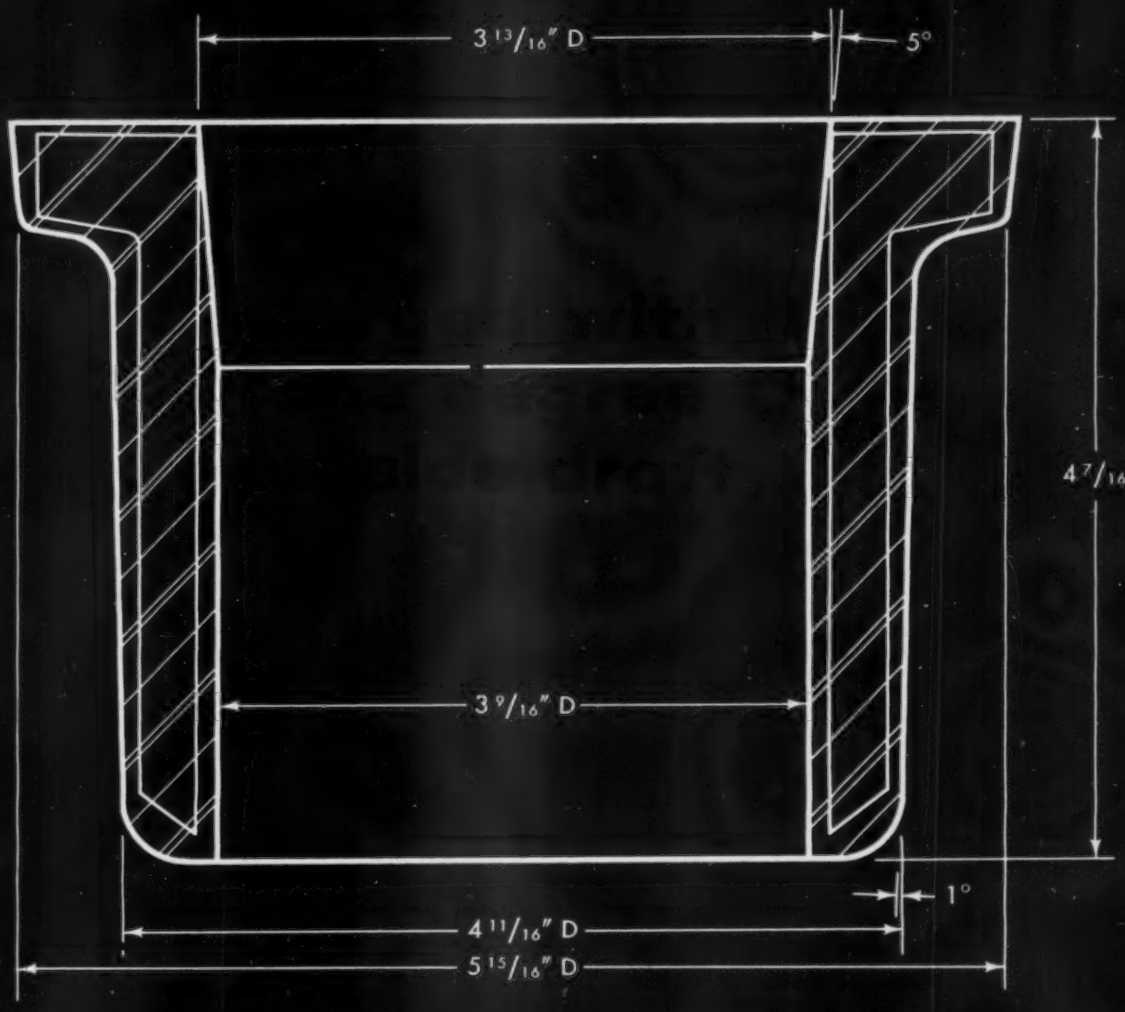
6. *Less scrap is generated.* Scrap produced in conventional operations frequently exceeds 30%; in the powder method it will be less than 4%.

A special application is the production of complex core materials for nuclear fuel elements (when these laminated cores are cold rolled or extruded in the wrought form, the uranium alloys often fracture, producing discontinuities).

Economics change with time

Like most new processes, powder metal rolling is economically a circular proposition. The chief economic disadvantage of the process is the relatively high cost of most metal

Forging superalloys—New facilities at Haynes Stellite Co.'s Kokomo, Ind. plant have been designed especially for forging superalloys. Because the cobalt and nickel-base alloys produced by Haynes have a limited hot working range, all of the forge equipment (like the press shown here) is designed for speedy operation. Ingots ranging from 1500 lb to 5 tons will be processed through the plant.



...to save metal and machining dollars

Forging with minimum external and internal drafts is a Bethlehem specialty. Witness the closure hub above.

We forge this part and others like it in a mechanical press to 1 degree outside draft, 5 degree inside draft. Then we hot-broach the inside draft to facilitate internal chucking. By the time this hub arrives at our customer's machine shop, little machining is required. Machining's a lot safer, easier, and faster, too. Because of the small drafts, chuck jaws can get a big bite on the part. They won't slip. Our customer can safely use higher horsepower machine tools, and speed his work.

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Morganite

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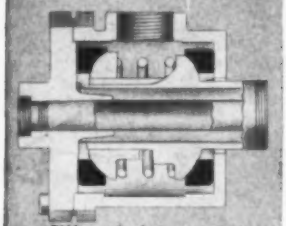
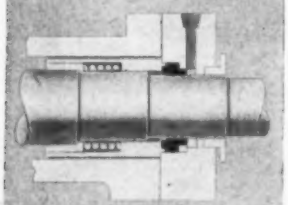


PY4 seal rings operate with highest efficiency in this rotary pressure joint carrying steam-condensate.



Mechanical seals with Morganite PY4 noses provide an extra measure of dependability in this stuffing box assembly.

LINK PY4 GRADE of self-lubricating MORGANITE is the engineer-preferred seal material for every application where premium performance is a "must." Actual service records compiled on PY4 Seals in all types of rigorous service, prove that this super-rugged material can take punishment! PY4 Seals function with highest efficiency in the presence of grease, searching liquids, corrosives, high pressures and high temperature. Install Morganite LINK PY4 for longer seal life . . . reduce down-time and save on seal replacement costs.

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For more information, turn to Reader Service card, circle No. 413

What's new IN MATERIALS

powders. Despite the high cost, the process seems feasible for many applications. And as these applications develop, new powder-producing capacity should develop. The probable result is an eventual drop in the price of existing metal powders. This trend—together with the development of new, low cost powders—would not only speed up the further development of powder rolling, but would also greatly encourage new applications of powder metallurgy to mechanical parts.

In general, strip rolled from powder seems to be economically most feasible at present for:

1. Nickel and copper, for which pure, inexpensive powders are available.
2. Hard-to-form materials, such as reactive and/or refractory metals and alloys (titanium, zirconium, tantalum, molybdenum).
3. Complex dispersion-type alloys and bimetals.

As for iron and steel most people in the powder metallurgy field agree that general, widespread application will have to wait until a good iron powder can be produced at nearly the cost of pig iron. Pickens is convinced that such a powder will be available within two or three years, and will probably be made by a hydrometallurgical process.

Even without such a powder, the low plant investment required will make the iron powder rolling process economically attractive. As Earle Smith points out, the process offers promise for many areas of the world where lack of convenient or economical ore and coal deposits, not to mention lack of capital, make tonnage production of pig iron virtually impossible.

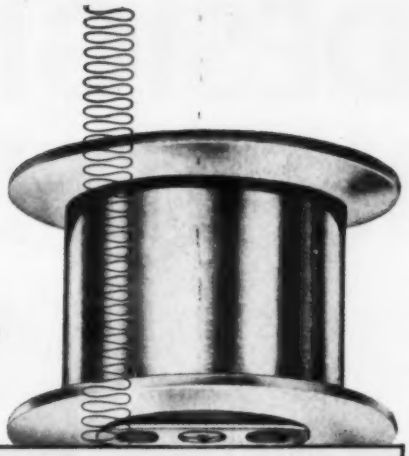
Many organizations are experimenting

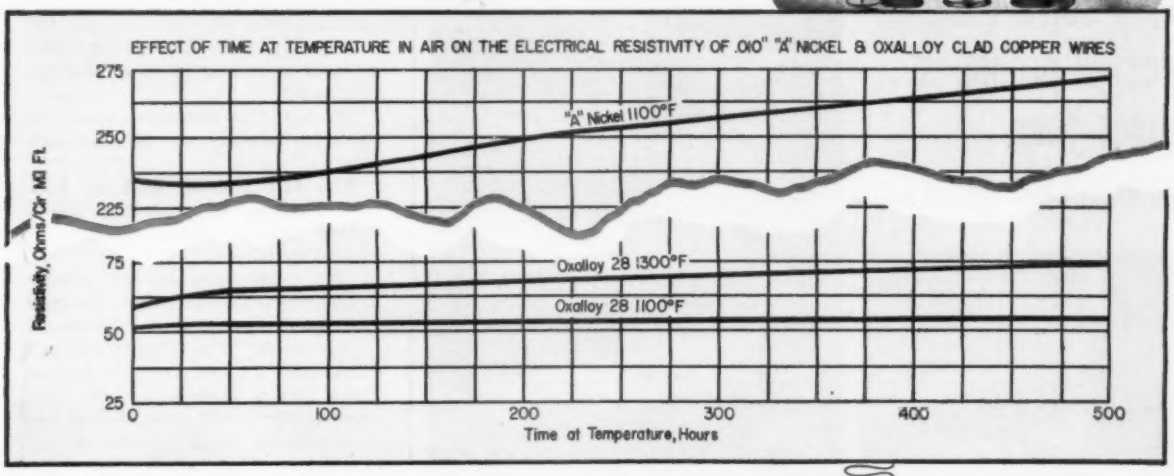
Approximately 20 companies and research organizations are thought to be actively engaged in powder rolling development in this country and Canada.

Much of this work has been done on nuclear metals and is still classified. At least two organizations are known to be particularly interested in aluminum. And early this year the Naval Ordnance Laboratory reported that continuous rolled strip of a nickel-iron magnetic alloy had

NEW

Sylvania Oxalloy* 28 Wire...





—nothing else is so stable, for so long, at such high temperatures

OXALLOY 28 is Sylvania's new copper wire clad 28% by weight with a chrome-iron alloy. This cladding provides excellent oxidation and corrosion-resistance at high temperatures, making OXALLOY 28 extremely reliable during prolonged exposure to temperatures as high as 1300° F.

If, in your wire application, high conductivity must be maintained for long periods of time—then OXALLOY 28 is meant for you. Compare the rate of change in resistivity of pure "A" nickel and Sylvania's new OXALLOY 28.

We would like to supply you with complete data on other properties of OXALLOY 28, Sylvania's new clad copper wire. Write to Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

Sylvania is the only major wire supplier with complete facilities for both plating and cladding wire. This makes it possible to provide you with an experienced, objective recommendation as to whether a plated or a clad wire is best suited for your application.

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Alloy, Clad, Plated Wire
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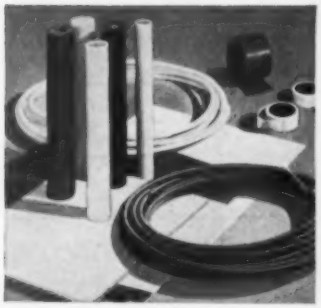
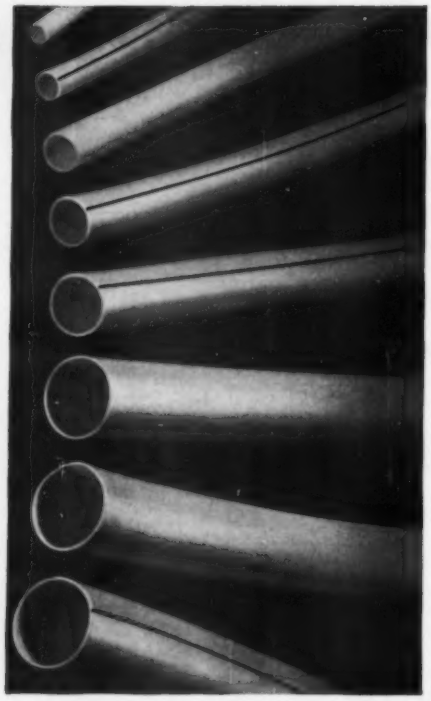
DESIGNING IN TEFLON*?

Let R/M's complete "Teflon" service help solve your design problems... meet your production needs



STANDARD FORMS. Tubes, rods, sheets, tape and thin-wall tubing are available. Also bondable "Teflon."



NEW STRIPED THIN-WALL TUBING can be supplied with identifying stripes in a variety of colors, for sure, quick identification.

Take advantage of R/M's broad experience in the design of "Teflon" parts and ample facilities for its fabrication. R/M sales engineers have cut costs for customers by suggesting a minor change in design—without affecting performance—or a more efficient method of fabrication. Where a standard form will do the job, R/M offers a vast array of "Teflon" sheets, rods, tubes, thin-wall tubing and tape . . . standard or bondable.

And R/M is constantly working to develop new varieties of "Teflon" products. Thin-wall tubing, for example, can now be furnished with permanent color striping for identification purposes. And 1/32-in.-thick "Teflon" can now be supplied in sheets 36 x 36 in. . . . greater thicknesses in 48 x 48 sheets. If you are designing in "Teflon," or considering its use, it will pay you to learn more about R/M's complete "Teflon" service. Contact your nearest R/M district office or write Plastics Products Division, Manheim, Pa.

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Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

For more information, turn to Reader Service card, circle No. 382

magnetic characteristics equivalent to those of the commercial alloy of the same composition.

Aside from copper, most published work has been on nickel. Both Sylvania and the University of British Columbia are rolling pure nickel strip from powder. Sherritt Gordon Mines, Ltd. in Canada uses a hydrometallurgical process to make a pure nickel powder especially suitable for rolling. Cost aside, high purity nickel strip is promising for electronic applications.

Among other companies known to be experimenting are Du Pont and Martin.

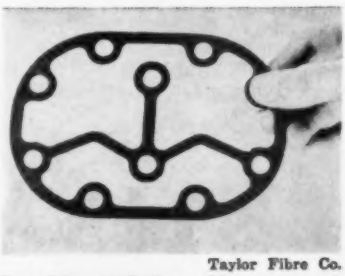
The fact remains that no full-scale commercial production line—either ferrous or nonferrous—is operating as yet.

But many men in the powder metallurgy field feel that the new way of producing flat mill products is inevitable. "The thing to realize," Chemetals' Pickens says, "is that we have here a whole new technology. Eventually it will make obsolete the conventional smelting, refining and fabrication of metals."

Rubber-Coated Fibre Makes Tough Gasket

A nitrile (NBR) rubber-coated vulcanized fibre gasketing material is said to combine the strength, density and fluid resistance properties of vulcanized fibre with the sealing properties of NBR rubber. The gasketing material, called Avronite, is available from Kalendex Corp., 26018 W. 7 Mile Rd., Detroit 19.

According to Taylor Fibre Co., the combination gasketing material is so



Taylor Fibre Co.

***Durable gasket** combines strength of vulcanized fibre with sealing properties of NBR rubber.*

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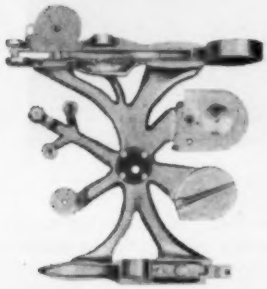
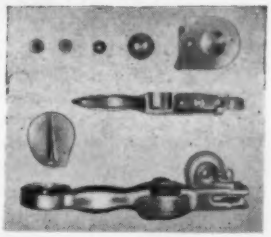


One Die . . .
One Shot . . .
8 PARTS !



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Each high-speed casting shot supplies practically all the major parts for this labeler. Subsequent trimming by Dollin, delivers these zinc parts with close accuracies and a smooth hardware finish, ready for finishing and assembly —at low piece cost

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SPECIFICATION STEEL CASTINGS

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What's new IN MATERIALS

durable that "in some instances it can replace metal-jacketed gasketing with cost savings up to 25%." The gaskets are said to effectively seal internal pressures as high as 750 psi at temperatures up to 300 F.

Gaskets made from the material are especially useful in truck or heavy automotive applications where oils and gasolines must be contained at relatively high pressures. They are also recommended where accurate spacing of gasket assemblies is vital, such as on side plates of vaned pumps where too little clearance can cause scraping of vanes and too much can cause slippage of fluid.

Glass Peening Cleans Metals Without Damage

A stream of microscopic glass beads electrostatically suspended in a solution is used to remove scale, corrosion, dirt, burrs and tool marks from ferrous and nonferrous metal parts. According to the developer, the peening method does not alter dimensions of parts being cleaned, does not contaminate or leave embedded particles in the part, and does not nick sharply machined edges or threads.

The peening method, called Perfecto-Peen, was developed by Aero-Test Equipment Co., Inc., 1601 Dragon St., Dallas 7, Tex. The glass peening method has successfully been used to clean cookware, heat exchangers, watch parts, mixing vats, storage tanks, aircraft, bearings, shafts and dies.

PVA Synthetic Fibers Are Strong, Tough

Tough, strong, abrasion resistant polyvinyl alcohol fibers, developed in Japan, are now being marketed in this country on a developmental

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Specific Gravity	1.28
Melting Point, F	420-450
Tenacity, gm/denier	4.4
Elongation, %	18
Modulus, gm/denier	40
Stiffness, gm/denier	24

*Specimen was 3-denier dull staple.

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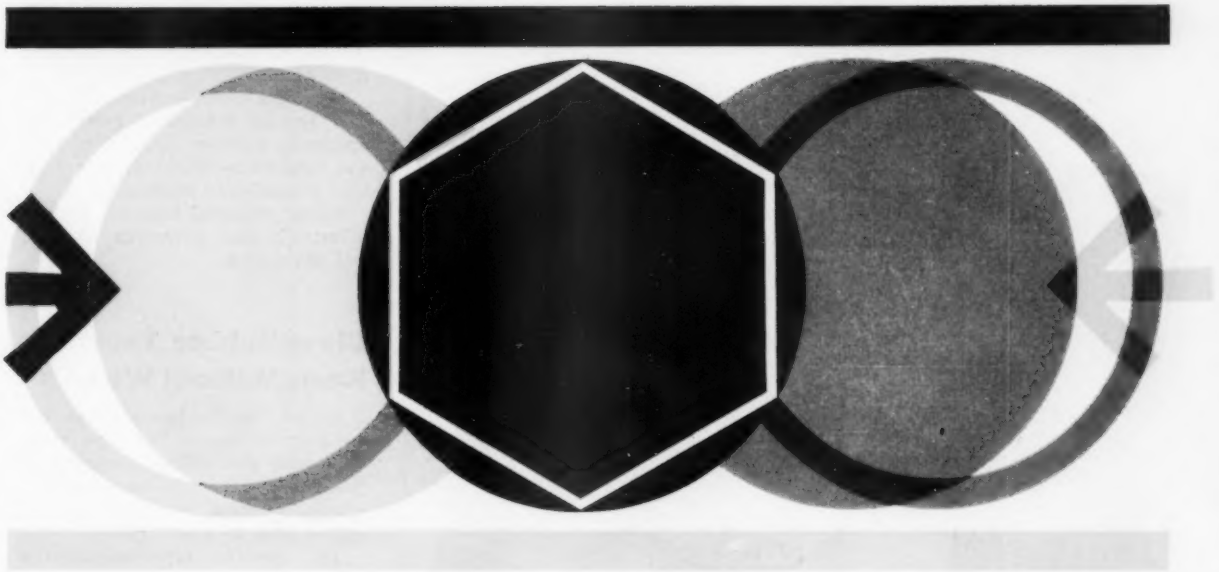

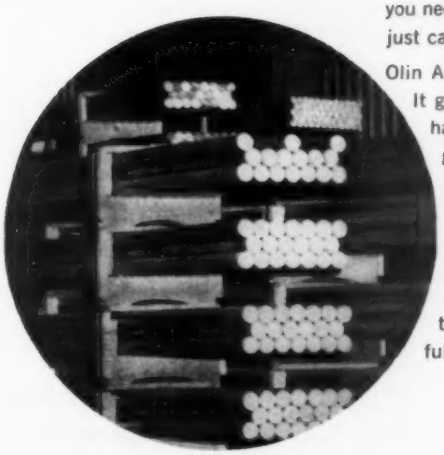

Olin STAK-PAK gives you easier handling and greater stackability... protects your stock against scratching and abrasion.

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Olin Aluminum is today's fast-moving, machinable metal. It gives you top-speed cutting. It's rapidly handled and shipped. It's cold processed for uniform grain size (a quality plus). You get three times as many parts per pound as you get with other metals and—in many cases—aluminum parts need no further finishing. You save many ways! What's more, you can always count on fast technical assistance from the design, metallurgical and technical services of Olin Aluminum—America's new, fully-integrated producer.

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Kopp Glass, INC.

Swissvale, Pennsylvania

For more information, turn to Reader Service card, circle No. 395

What's new IN MATERIALS

basis. The fibers, called Vinylon, are available in the form of staple and tow from the Fiber Dept., Air Reduction Chemical Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17.

According to the producer, Vinylon fiber has an unmatched balance of properties between those of natural and man-made fibers. It has high tear strength and pleasing hand.

Among potential uses are various industrial and nonwoven fabrics, and upholstery.

Glass-Rubber Tape Heats Without Wires

A new flexible heating tape has no electrical wires. The tape, made of woven glass fibers impregnated with conductive silicone rubber, is merely plugged into an electrical source such as a battery.

The wire-free tape maintains a uniform temperature at any spot on its surface. It can be used continuously at 400 F and intermittently at 600 F. It was developed by Sunelec Inc., P. O. Box 1139, Trenton, N.J.

The tape is expected to find use in plastics products such as dinnerware, baby items, automobile heaters and floor mats. It is also expected to find use in electric blankets, heating pads and lightweight clothing. It is presently being used for the heating ignition batteries in cold climates.

The tape is supplied in widths from ½ to 6 in. and in thicknesses from 0.005 to 0.012 in. in any length.

Straight Brass Rod for Screw Machines

Chase Brass & Copper Co., Metallurgical Dept., Waterbury 20, Conn. has introduced a free-cutting brass rod with controlled straightness. The straightness of round rod is controlled to ±¼ in. in a 10-ft length; the straightness of hexagonal, octagonal and square rod is controlled to ±⅜ in. in a 10-ft length.

The straightness of the rod is said to reduce the whip associated with rod of lesser straightness. Whip can cause short feed on long parts and

"SHELVED" PROJECTS NOW POSSIBLE

Super Alloys key to advanced development work

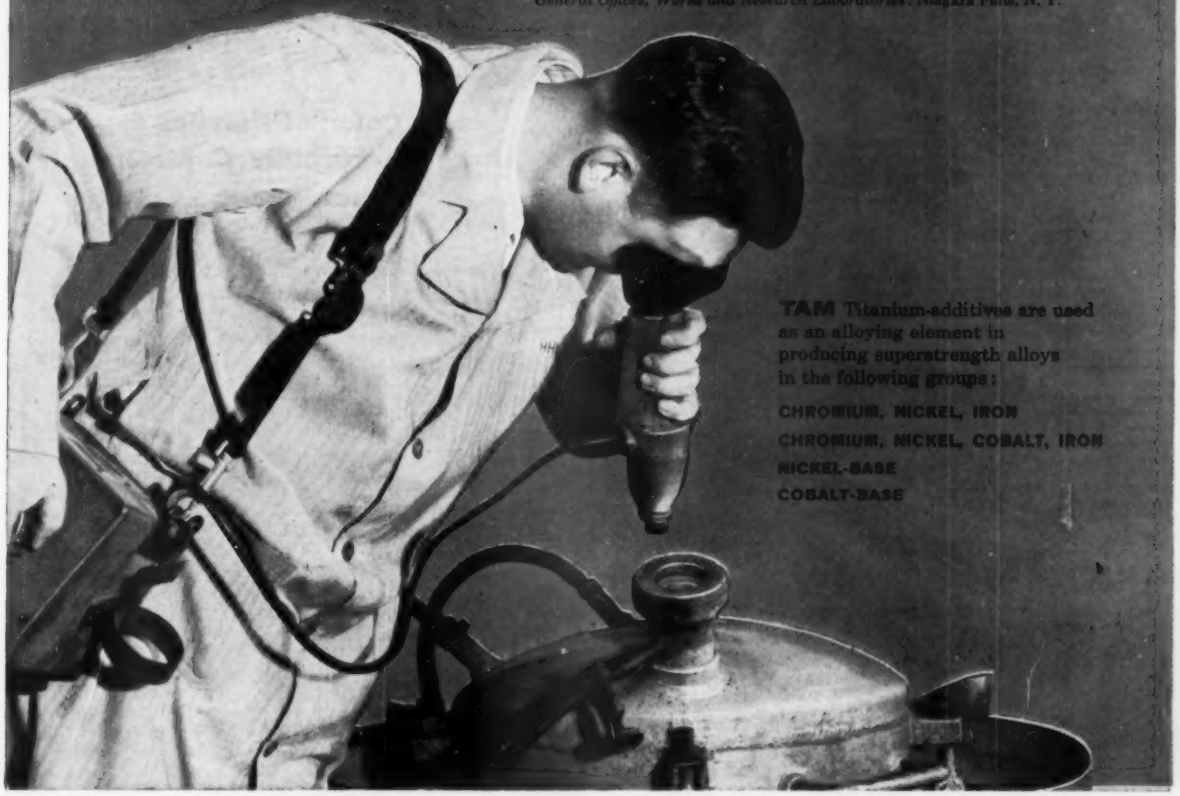
Marked improvement in elevated temperature properties of new superstrength alloys is permitting design engineers to move ahead on projects once considered impractical. This is perhaps most evident in the aircraft, missile, jet and turbine power fields. It is, by no means, limited to these alone.

Using advanced techniques and processes, metallurgists are producing a variety of new and improved alloys with superior physical properties.

Where strength at elevated temperatures is the major factor, alloys containing Titanium as the alloying element offer many practical advantages. We suggest that investigation of these titanium-bearing alloys now may lead to the design and production of end products with many new application possibilities. A letter to our NYC office can be a logical first step to getting certain projects off the shelf and into being.

TAM
DIVISION NATIONAL LEAD COMPANY

Executive Offices: 111 Broadway, New York City
General Offices, Works and Research Laboratories: Niagara Falls, N. Y.



TAM Titanium-additives are used as an alloying element in producing superstrength alloys in the following groups:

CHROMIUM, NICKEL, IRON
CHROMIUM, NICKEL, COBALT, IRON
NICKEL-BASE
COBALT-BASE

For more information, turn to Reader Service card, circle No. 498

New Star Performer In The Sandvik Line

SANDVIK

Presents A SUPER SPRING STEEL

Sandvik's new 2R25 is a superior grade of stainless spring steel which goes far beyond the capabilities of ordinary spring steels. It was developed for applications where performance outranks cost.

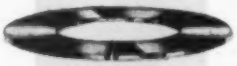
This new steel is a prime example of Sandvik's ability to combine several advantageous properties in one metal. *Sandvik 2R25 is exceptionally tough and resilient, much more formable than hardened and tempered steel, has up to 10 times the fatigue life of ordinary carbon spring steel and has excellent corrosion resistance under varying atmospheric conditions.*

Mechanical Data on 2R25—
TENSILE STRENGTH RANGE—
Hard Rolled 242,000 • 270,000 or 299,000 PSI
Heat Treated 270,000 • 299,000 or 327,000 PSI
ELASTIC LIMIT (.01% Proof Stress)—From 156,000 to 192,000 PSI according to size and finish
MODULUS OF ELASTICITY—27.7 to 35.6 x 10^6 PSI according to size and finish
SIZES (with extremely close tolerances)
Thickness—.0016" to .035", Width—.039" to 3.94"
For further information on Sandvik 2R25, contact your nearest Sandvik office.

Hardened & Tempered Spring Steel

Annealed Spring Steel

Band Saw Steels


Flapper Valve Steel

Piston Ring Steels

Razor Blade Steel

Shock Absorber Steel

Sandvik stocks a wide variety of qualities and sizes of cold rolled specialty strip steels. In addition Sandvik has rolling, slitting, edge-filing and hardening and tempering facilities. *Send for your copy of this free brochure* which gives specific data on the leading types of Sandvik steels.

SANDVIK STEEL, INC.
1702 Nevins Road, Fair Lawn, N. J.
Tel. SWorthmore 7-6200 • In N. Y. C. Algonquin 5-2200
Branch Offices: Cleveland • Detroit • Chicago • Los Angeles
SANDVIK CANADIAN LTD. P.O. Drawer 1335, Sta. O. Montreal 9, P. Q.
Works: Sandviken, Sweden

For more information, turn to Reader Service card, circle No. 451

***Production line testing** of brass rod for straightness is done by rolling rod on an extremely flat metal surface.*

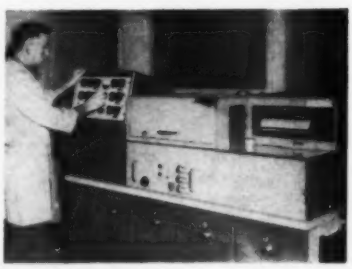
can present difficulties in maintaining close tolerances on finished products. The lower whip of the new rod is also said to result in quieter operation of high speed screw machines.

The newly improved rod is said to offer all the advantages previously associated with free-cutting brass, such as ease of machining, low scrap rate and long tool life. The brass rod is called 3 Mark.

Color of Plastics Is Accurately Controlled

Color controlled polystyrene molding compounds are now commercially available from Monsanto Chemical Co., Plastics Div., Springfield, Mass.

The colored plastics compounds are produced by a color system known as Micro-Match. The theory on which the system is based takes into account the three color variables of hue, purity and value, and plots



***Spectrophotometer** is used by Monsanto Chemical Co. to control color of its polystyrene molding compounds.*

For more information, turn to Reader Service card, circle No. 452

we specialize in *CURVED SHAPES!*

(metalformed, that is!)

Spinnings, like women, come in all shapes and sizes. But when you have man-sized equipment and years of experience, even the most resistant conformations fall into line. Spincraft has that equipment in its exclusive, specially-built MET-L-FLO automation lathes — available nowhere else. It has the experience, too, in forty years of creative metalspinning for industry's newest developments.

In rockets and missiles, for example, Spincraft has been in there from the very beginning. The sheath dress the lady is wearing is actually a thrust nozzle for the early Hermes missile. The trapeze dress is a section of the Honest John rocket. And the chemise is the preform stage of countless spinning jobs in missiles and other fields.

If you have metalforming problems on your drawing boards, Spincraft can solve them for you more quickly, efficiently, and economically than you may think possible. Send prints for quotation, or call in one of our skilled SPINGINEERS.

SEND FOR: *Notes for An Engineer's File*, continuing series of technical bulletins keeping you abreast of the latest metalspinning advances in the world's largest metalspinning plant.

Spincraft
SKILL WILL DO IT ®
INCORPORATED

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4125 West State Street, Milwaukee 8, Wisconsin

The Proof of the Drawing is in the Prints

DAMASCUS
does the job better

Make this test. Compare the prints from drawings made by your present pencil and Damascus Drawing. Look for broken lines, light spots, uneven line edges. You will agree that Damascus gives you sharper, blacker prints—as good as your drawings. Reproduces beautifully on MYLAR.

Send for free sample kit of Damascus Drawing pencils. Or ask the man who knows—Your Blueprinter.

R B Richard Best Pencil Company
Springfield, New Jersey

For more information, turn to Reader Service card, circle No. 368

Cut Finishing Costs THROUGH INCREASED PRODUCTION

CLAMPS AND FIXTURES
Positive pressure and exact registration of the part in the mask. Reduce rejects. Free both hands for productive movements.

AUTOMATIC MACHINES
Increase production hundreds to one over hand methods. Reduce labor costs. Eliminate need of experienced workmen.

MASK WASHING MACHINES
50% faster than any other make. Cut solvent consumption. Avert production delays due to damaging of masks by hand scrubbing.

SPRAY PAINTING MASKS
A competent engineering staff will counsel with you on the most efficient technique for handling your particular requirements.

C-M
Send for Free Literature Now!
Conforming Matrix CORPORATION
386 TOLEDO FACTORIES BUILDING TOLEDO 2, OHIO

For more information, turn to Reader Service card, circle No. 443

THERMAL SHOCK

A CASE IN POINT—This 20 pound Ni-Resist casting made for the Schwitzer Corporation by Hamilton Foundry is the turbine casing of a diesel engine turbocharger. Exhaust gases which turn the impeller at speeds up to 90,000 rpm subject the housing to rapid cyclic temperature changes up to 1500° F. Any free scale formed at these temperatures could erode and eventually destroy the impeller blades. Ni-Resist was chosen for this part because it produces practically no free scale, it resists growth and oxidation at high temperatures, and it resists cracking under thermal shock.

Ni-Resist iron combines three particular product engineering and design advantages. It resists oxidation: as low as .002 inches per year oxide penetration at 1400° F. Scale formed adheres to the base metal and reduces further oxidation to a minimum. It has high temperature strength: up to 12,000 psi at 1500° F. And it's the toughest of all flake graphite irons: Charpy impact strengths (unnotched) up to 150 ft.-lbs. Hamilton Foundry casts all types of Ni-Resist including Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

For more information, turn to Reader Service card, circle No. 464

them on a three-dimensional graph somewhat comparable to the spherical shape of the earth. According to Monsanto, every color in the spectrum can be located on this dimensional graph by its "latitude," "longitude" and "distance from the center of the earth." These color measurements are said to be absolute. Heretofore, color of plastics compounds was controlled by visual methods.

The new color system, which uses a spectrophotometer combined with a specially designed computer, can detect and allow correction of color variations unnoticeable to the human eye. Data supplied with each shipment verify that the color of the polystyrene compound matches that of past shipments.

Magnesia Ceramic Withstands 4300 F

An extremely pure magnesia ceramic (99.8% pure) is capable of long term operation at temperatures up to 4350 F. It was developed by Corning Glass Works, Corning, N. Y.

Melting point of the dense, nonporous magnesia is over 5000 F, and it has the thermal characteristics of an ablating material. The new magnesia ceramic can be slip cast, pressed or extruded into a variety of shapes. It is suitable for refractory and electrical applications.

Phosphorescent Paints Are Self-Luminous

Two nonradioactive phosphorescent paints that glow in the dark without the aid of black light or other external excitation are now available from Ultra-Violet Products, Inc., San Gabriel, Calif.

The paints are visible in darkness at distances up to 150 ft. Both paints have long storage stability with no skinning or settling. They are expected to be used on fire extinguishers, first aid kits, stair treads, camping and fishing equipment, light switches and patio furniture. They sell for $69 per gal.

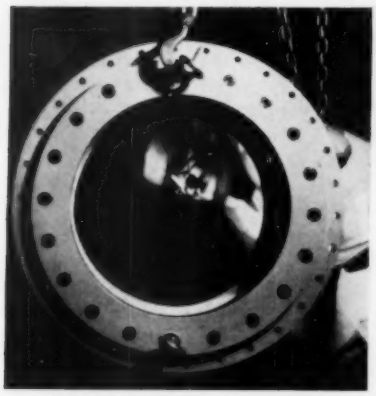
A-540 is an air dry enamel that dries to the touch in 1 hr. The dried paint has good resistance to salt

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

NEW PICTURE WINDOWS FOR NAVY'S NUCLEAR REACTORS

In the "older" models of the Navy's nuclear subs, a periscope was used for checking reactor operation.



Not so in today's subs. Now you'll find giant peepholes—windows that let you look directly into nuclear compartments.

These windows are made from a combination of Corning high-lead-content glass and a plastic. The latter shields against neutron bombardment. The high density *glass* (6.2 cc, the equal of iron for shielding) protects against gamma rays.

Just for the record, seagoing radiation windows are only one part of a rather extensive line that Corning makes.

To date, for example, we've handled the shielding window problems of some 200 "hot" cells. Such windows often approach Gargantuan proportions . . . like the five-foot-thick, nine-ton job we finished recently.

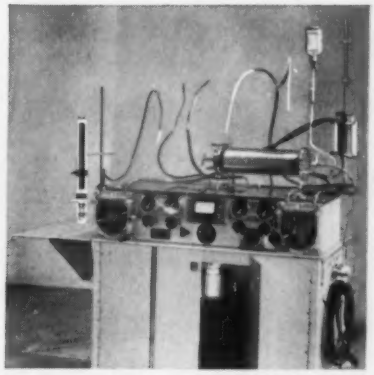
The big advantage for you, the user, in all this . . . aside from the fact that you can get any combination of three very special glasses we make for shielding . . . is *simplicity*. You just tell us your energy level, wall thickness, and the viewing area you need. We do the rest . . . ship you a window that's *ready to install*. It's as easy as that.

Added incentive: The most recent design change we've come up with involves a more pronounced *taper* than was previously used. This makes for less weight, easier installation, better fit.

Delve further into this subject by checking the box in the coupon, labeled "Radiation Shielding Windows." This will bring you a detailed booklet. Or drop a note outlining what's on your mind to Plant Equipment Sales Department.

THE HEART OF THE MATTER

During certain operations involving the heart, both the heart and lungs are given a rest.



But the functions of these organs still must go on. So ingenious machines take over. Like the Kay-Cross rotating disc oxygenator that does the work of the lungs, controlling the CO_2 and putting in pure oxygen.

The main component of this oxygenator is a series of discs, so designed that blood spreads out without foaming or bubbling.

Comes the commercial. These metal discs must be enclosed in a container. And the people who make the oxygenator, Pemco, Inc., chose a PYREX brand glass to hold the discs.

For good reasons. First off, this PYREX brand glass lets you keep careful watch over the *color* and *flow* of the blood, both very vital considerations to the medical men who use this machine.

Then, this PYREX brand glass is *inert* chemically. It does not add to or take from the blood in any way. There is no pickup, no side effects.

And, because this glass has a low coefficient of thermal expansion, 32 x 10^{-7}in/in/°C., the entire machine can be steam sterilized *without* any fear of danger from thermal shock.

While this particular application may be far afield from your work, one of the PYREX brand glasses may still turn out to be the answer to one of the tough design problems you are now facing.

You'll find that this transparent, corrosion- and thermal-shock-resistant glass is available in rod, tubing and flat glass. And it can be worked into a wide variety of special shapes by automatic pressing and blowing machinery.

Perhaps the best approach for you is to avail yourself of two well-detailed reference folders, B-83, "Properties of Selected Commercial Glasses," and IZ-1, "Designing with Glass for Industrial, Commercial and Consumer Applications." Use the coupon.

YOU CAN MAKE GLASS BREAK THE WAY YOU WANT WHEN YOU WANT

Tempered glass breaks in a very special way—we call it "dicing"—and that has led to some very special uses:

Rupture discs—Say you're holding a liquid or a gas in a container and at some precise moment you want to release it suddenly and smoothly. You can insert a tempered glass disc in your container, a disc that has been prepared to disintegrate at a given pressure.

The pressure can be applied by the fluid or by a small charge attached to the disc. When you want it to go, the glass will shatter instantaneously and homogeneously into small pieces.

Probable uses for this include safety valves on process equipment and as a substitute for intricate valving on fuel injection systems. Using PYREX brand Glass No. 7740, you can cross corrosion off as an inhibiting factor on valves. Pressure ranges run from 100 to 1000 psi.

Metal samples and billiard balls—Glass is also being used in the form of tubes to remove samples from molten metals . . . the glass crazes but holds together long enough for your sample to cool into a smooth cast; then you strip off the glass and you're ready for analysis. The plastics people are using glass molds where they want smooth surfaces . . . billiard balls, for example; when the plastic cools you just chip away the glass.

Want glass that breaks how and when you want it? Write to our Industrial Components Sales Department, spelling out your problem.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 50-8 Crystal Street, Corning, N.Y.

Please send me: ☐ "Radiation Shielding Windows"; ☐ Bulletin B-83; ☐ Bulletin IZ-1

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 371

FOR HIGH SPEED FABRICATION

NEW INSUROK®

Free-Machining, Laminated, Rolled Tubes Meet Mil-P-79B and Federal L-L-3

INSUROK GRADE	NEMA GRADE	MILITARY SPECIFICATIONS	FEDERAL SPECIFICATIONS
T-300	X	Mil-P-79B, Type PBM, Form TR	L-L-31, Type 1, Grade X
T-301	XX	Mil-P-79B, Type PBG, Form TR	L-L-31, Type 1, Grade XX

T-300 and T-301—two new, improved grades of INSUROK paper base, laminated tubes are distinguished by their excellent FREE MACHINING characteristics. They do not chip or delaminate when fabricated. Having good dielectric properties and uniform appearance, these light colored INSUROK tubes are suited to any fabricating operation. You can machine INSUROK T-300 and T-301 at top operating speeds.

For your electrical and mechanical applications you are offered a wide choice of tube sizes in these new grades:

• Inside diameters up to 12 inches • Wall thicknesses up to 2 inches

CHARACTERISTIC PROPERTY COMPARISON

CHARACTERISTIC PROPERTIES	NEMA XX REQUIREMENTS	T-301 TYPICAL VALUES
	Test Samples From 1" x 1¼" Tubes	
Water Absorption	2% maximum	1%
Density (grams per CM^3)	1.12 minimum	1.25
Dielectric Strength (perpendicular to laminations)	290 volts/mil. minimum	400 volts/mil.

Richardson offers a complete line of INSUROK laminated grades in sheets, rods and tubes . . . also provides complete fabrication service at its Melrose Park, Illinois and New Brunswick, New Jersey plants.

For full information on INSUROK T-300 and T-301, write direct or contact sales offices in principal cities.

the RICHARDSON COMPANY

LAMINATED AND MOLDED PLASTICS Founded 1858

2782 LAKE STREET • MELROSE PARK, ILLINOIS • SALES OFFICES IN PRINCIPAL CITIES

For more information, turn to Reader Service card, circle No. 465

spray, sunlight and general weathering. One gallon covers approximately 200 sq ft.

A-550 is a baking enamel that dries in 30 to 60 min at 150 to 175 F. The dried paint has good durability, high gloss, smooth finish, good weathering properties and good chemical resistance. One gallon covers approximately 175 sq ft.

Columbium Alloys Strong at 2000 F

Two high temperature columbium-base alloys for rockets and missiles are now commercially available from Fansteel Metallurgical Corp., North Chicago, Ill. The alloys are supplied in the form of ingots, forgings, bars, rods, sheets, plates and fabricated parts.

Fansteel 82 is a columbium-tantalum-zirconium alloy. It has a tensile strength of approximately 30,000 psi at 2000 F and 12,000 at 2400 F in air. The 10-hr stress-to-rupture strength at 2000 F is 26,000 psi. The reversed bending fatigue properties of Fansteel 82 show an endurance limit of 3×10^6 cycles at 30,000 psi and 2000 F for 16 hr. The alloy has good oxidation resistance.

Fansteel 80 is a columbium-zirconium alloy with a lower melting point and lower density than Fansteel 82. It has a higher strength-to-weight ratio than Fansteel 82. Oxidation resistance is comparable to that of pure columbium.

Both alloys are easily fabricated at room temperature either in the as-worked or annealed state. Both have excellent weldability, with ductile welds and little or no ten-

PROPERTIES OF COLUMBIUM-BASE ALLOYS

Type→	80	82
PHYSICAL PROPERTIES		
Specific Gravity, lb/cu in.	0.311	0.371
Melting Point, F	4350	4550
MECHANICAL PROPERTIES[a]		
Tensile Strength, psi	62,000	80,300
Elong (in 2 in.), %	3	3
Rockwell Hardness	F100	F107

[a]Tests performed on 0.040-in. thick sheet in the as-rolled condition.

DESIGNED IN CELANESE FORTIFLEX...

Hose manufactured for Eureka Williams Corporation, Bloomington, Ill., by Lawrence Hose Company, Trenton, N. J. Fortiflex filament, Reevon, supplied by Reeves Brothers, Inc., New York 18, N. Y.

Hose armored with Fortiflex filament helps Eureka make tough cleaning jobs go lightly

Because the outer braid is woven of Celanese Fortiflex filament, this hose is strong and abrasion-resistant. It's easier to use—lighter, more flexible—thanks to the thin wall section made possible by the high strength of Fortiflex. Smooth, colorful, with a handsome pattern in the weave and a surface that is easily cleaned, this hose typifies the advantages Fortiflex filament has to offer designers.

Fortiflex, a linear polyethylene, has much greater stiffness, hardness, strength and heat-resistance than the chemically-similar soft polyethylenes. For example, it can be sterilized in boiling water. Filaments drawn from this material have high tensile strength, toughness and durability. The high tenacity of the filament is partly due to a multiple stretching process. This orients the molecules, aligning them in the direction of stress. The high strength of the filament is accompanied by low elongation and excellent low-temperature resistance. Here is a design material which is ideal for making hoses, automotive seat covers, outdoor furniture webbing,* industrial filter cloths, fishing nets* and many other products.

Celanese supplies Fortiflex plastic for further processing into fibers. We'll be glad to put you in touch with manufacturers who produce and sell the filament, and we welcome inquiries as to properties and applications of Fortiflex filament. Simply clip and send us the coupon at right.

Celanese® Fortiflex®

TYPICAL PROPERTIES OF FORTIFLEX FILAMENT
(12-mil gauge)

Specific Gravity	0.950 to 0.960
Tenacity (grams/denier)	4.5 to 8.0
Tensile Strength, psi	55,000 to 100,000
Elongation, per cent	14 to 30
Knot Strength, psi	40,000
Loop Strength, psi	60,000
Water Resistance	Excellent
Ultraviolet Stability	Good*

*When properly pigmented and stabilized

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16.

For more information, turn to Reader Service card, circle No. 444

Celanese Corporation of America, Plastics Division, Dept. [illegible] 744 Broad Street, Newark 2, N. J.

Please send ☐ More information on Fortiflex filament. ☐ Names of manufacturers.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

makes Fluoroflex®-T pipe permanently corrosion-proof

USING the pipe lining *material* that handles highly corrosive fluids is only half the job. Keeping it *in place*, despite wide temperature fluctuations, is equally important. Fluoroflex-T Type S piping solves both problems . . . assuring unequalled pipe and fitting life.

Lining is universally inert to all corrosives. It's made of Fluoroflex-T, a high density, non-porous compound* of virgin Teflon.

Liner and housing in thermal equilibrium, through an exclusive process developed by Resistoflex. It compensates for thermal expansion differential between the Teflon and housing, eliminating fatigue collapse, and cracking at the flare.

Bulletin TS-1A gives more details. Write Dept. 171, RESISTOFLEX CORPORATION, Roseland, N. J. Other plants: Burbank, Calif.; Dallas, Tex.

* *Pat. No. 2,752,637*

®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
®Teflon is DuPont's trademark for TFE Fluorocarbon resins.

RESISTOFLEX

For more information, turn to Reader Service card, circle No. 427

ELEVATED TEMPERATURE PROPERTIES OF FANSTEEL 82[a]

Tensile Strength, psi	
2000 F in Argon	44,700
2000 F in Air	29,600
2400 F in Air	11,700
Yield Strength, psi	
1600 F in Air	39,600
2000 F in Air	27,400
Elongation (in 2 in.), %	
1600 F in Air	4
2000 F in Argon	8
2000 F in Air	2

[a]Tests performed on specimens prepared from swaged rod.

dency to fracture in the heat affected zones. The ductile-to-brittle transition temperatures in the annealed state are well below room temperature, according to the producer.

Nickel-Base Alloy Resists Fluoride Salts

A new nickel-base alloy, developed as a container material for molten fluoride salts, is now being produced

PROPERTIES OF HASTELLOY N SHEET

COMPOSITION, %	Cr 6.0-8.0, Mo 15.0-18.0, Fe 5.0, Si 0.5, Mn 0.8, C 0.04-0.08, B 0.01, S 0.03, Al+Ti 0.5, Ni 67.0-72.0
PHYSICAL PROPERTIES	
Density, lb/cu in	0.317
Melting Point Range, F	2370-2430
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	66.7
Spec Ht, Btu/lb/°F	0.095
Elec Res, microhm-cm	139
MECHANICAL PROPERTIES[a]	
Ten Str, psi	
Rm Temp	115,100
1300 F	69,600
1700 F	34,000
Yld Str (0.2% offset), psi	
Rm Temp	45,500
1300 F	31,600
1700 F	25,900
Elong (in 2 in.), %	
Rm Temp	50.7
1300 F	30.0
1700 F	30.0
Mod of Elast, 10^6 psi	
Rm Temp	31.3
1300 F	27.0
1700 F	18.2

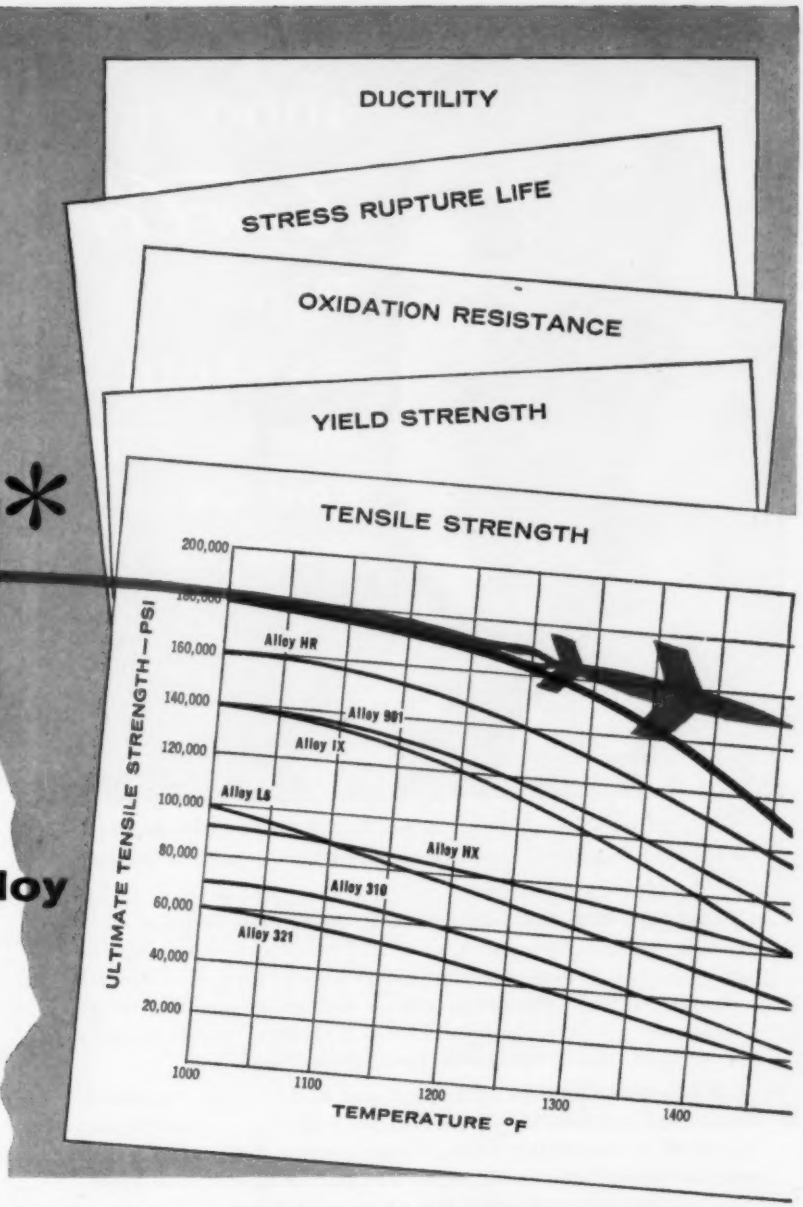
[a]Tests performed on 0.063-in. thick sheet heat treated at 2150 F, room air cooled.

HIGH

on every chart:

RENÉ 41*

most dependable alloy in use today in the 1200°- 1800° F range



In *all* ways, René 41 is a remarkable alloy. No other high-temperature alloy used in production today equals its tensile strength. In other properties, too, René 41 is far ahead of the field.

Also important, this nickel-base, vacuum-melted alloy is easy to work with. It's readily formable by drawing, bending, spinning — welds to similar or dissimilar materials.

Cannon-Muskegon offers René 41 in standard 36″x 96″ sheets .015″ to .125″ thick, in smaller sizes down to .010″, in bar stock up to 3″ in diameter . . . foil down to .001 in thickness . . . and fine wire only .0015 in diameter.

For complete details, write for Technical bulletin No. 86.

*TM of General Electric Co.

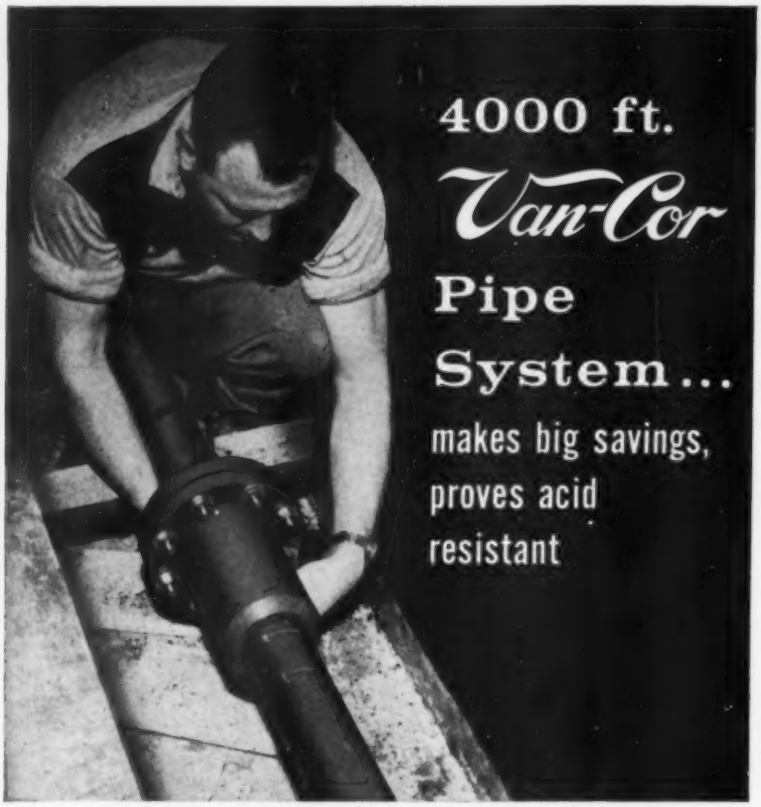
ULTRA MET
VACUUM ALLOYS

CANNON-MUSKEGON CORPORATION

2873 Lincoln Avenue • Muskegon, Michigan

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service card, circle No. 408



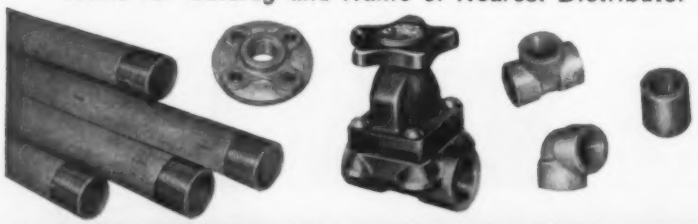
At the Allentown (Pa.) Works of the Western Electric Co., the entire waste acid disposal system in the recent addition consists of Van-Cor rigid PVC pipe and fittings.

HOW COSTS WERE CUT. Initial price of Van-Cor was ⅓ that of comparable cast iron alloy pipe. On a 6" line, labor costs were estimated at 29¢ per foot of run—about half that of metallic pipe. Also, because Van-Cor has only 1/10 the weight, no mechanized handling equipment was needed. Available in 10 or 20 ft. lengths, Van-Cor requires fewer joints, and eliminates the breakage problem.

CORROSION LICKED. Van-Cor pipe was used because "corrosion resistant" cast metallic pipe had performed short of expectations in an adjacent building. After 1½ years service, the Van-Cor system is in excellent shape, unaffected by such acids as hydrofluoric, hydrochloric, sulphuric, nitric and many plating solutions.

Investigate Van-Cor Pipe, Fittings, Valves, Electrical Conduit, and Fabrications . . .

Write for Catalog and Name of Nearest Distributor



INDUSTRIAL DIVISION OF...
COLONIAL PLASTICS MFG. CO.
Subsidiary of THE VAN DORN IRON WORKS CO.
2685 EAST 79TH STREET CLEVELAND 4, OHIO

For more information, turn to Reader Service card, circle No. 393

What's new IN MATERIALS

CORROSION RESISTANCE OF HASTELLOY N SHEET

Chemical	Conc, % by wt	Temp, F	Penetration, mils/yr
Hydrochloric Acid	2	Room	1.2
	2	150	18.4
	5	Room	1.1
	5	150	19.6
	25	Room	1.8
	37	Room	0.8
Sulfuric Acid	5	Room	1.2
	5	150	11.5
	25	Room	1.0
	25	150	10.3
	50	Room	0.9
	96	Room	0.9
Ferric Chloride	2	Room	1.1
Phosphoric Acid	10	Room	0.8
	10	150	1.2
	30	Room	0.9
	30	150	1.3
	85	Room	0.6
Hydrofluoric Acid	5	Room	1.5
	25	Room	3.0
	45	Room	4.6
Acetic Acid	10	Room	1.0
	10	150	2.7
	50	150	2.5
	99	Room	0.7
	99	150	0.7

on a developmental basis by Haynes Stellite Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17. An outstanding characteristic of the alloy is its good resistance to embrittlement upon continuous exposure to temperatures is high as v600F. The material, called Hastelloy N, evolved from work done at Oak Ridge National Laboratories.

The alloy can be supplied to order in the form of sheet, plate, bar, wire and coated welding electrodes. It can also be supplied as sand, shell and

MECHANICAL PROPERTIES OF HASTELLOY N CASTINGS[a]

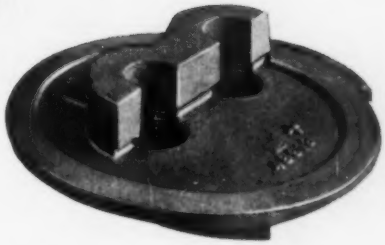
Process →	Sand	Investment
Ten Str, psi	86,800	86,400
Yld Str (0.2% offset), psi	40,200	37,300
Elong (in 1 in.), %	22.0	16.8
Mod of Elast, 10^6 psi	26.2	43.0

[a]Heat treated 30 min at 2150 F, room air cooled.

THE DODGE STEEL ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

How to design better steel castings

Here are a few tips on how you can obtain better steel castings through improved specification practices and design techniques. By observing these basic suggestions, you can design steel castings that meet strict service requirements, and save time and money, too!



A SOUND APPROACH

Where steel castings are concerned, efficient design goes well beyond merely creating a strong, attractive product. Too often, high unit costs, wasteful rejects, and time-consuming machining problems are designed into a steel casting *before* it reaches the foundry! Here's how to avoid some of these costly pitfalls:

It is important to establish specific service conditions for the casting. And, an accurate determination of critical requirements may make all the difference in the degree of quality as well as economy you achieve.

Unnecessary close dimensional tolerances in your design and undue variation of metal thickness will result in increased labor and material costs. If possible, contact your foundry when reducing the quantity of metal in your casting or when you have a complicated design. Sometimes thin metal sections and complexity is costly.

SELECT THE METAL

Before making your final design, it is wise to make a tentative choice of the steel to be used. A design adequate for one type of steel can cause trouble for another. The properties of steels—ranging from low-carbon varieties to high-alloy steels—vary widely in toughness, durability, and ductility, as well as in machining and weldability.

Accurate evaluation of service conditions can improve your choice. Steel castings are usually supplied normalized and drawn. Quenching, tempering, and hardening produce a broad range of properties which are best considered before making your final selection. Once the proper steel is chosen, a design tailored to its particular characteristics will often simplify foundry techniques.

IMPORTANT POINT

Discussing your proposed design with your foundry is highly important where costs are concerned. It's a rare case where suggestions can't be made that will simplify foundry practice and cut down on labor or material. We will be happy to have a Dodge Steel Casting Engineer discuss your design problems with you without obligation.

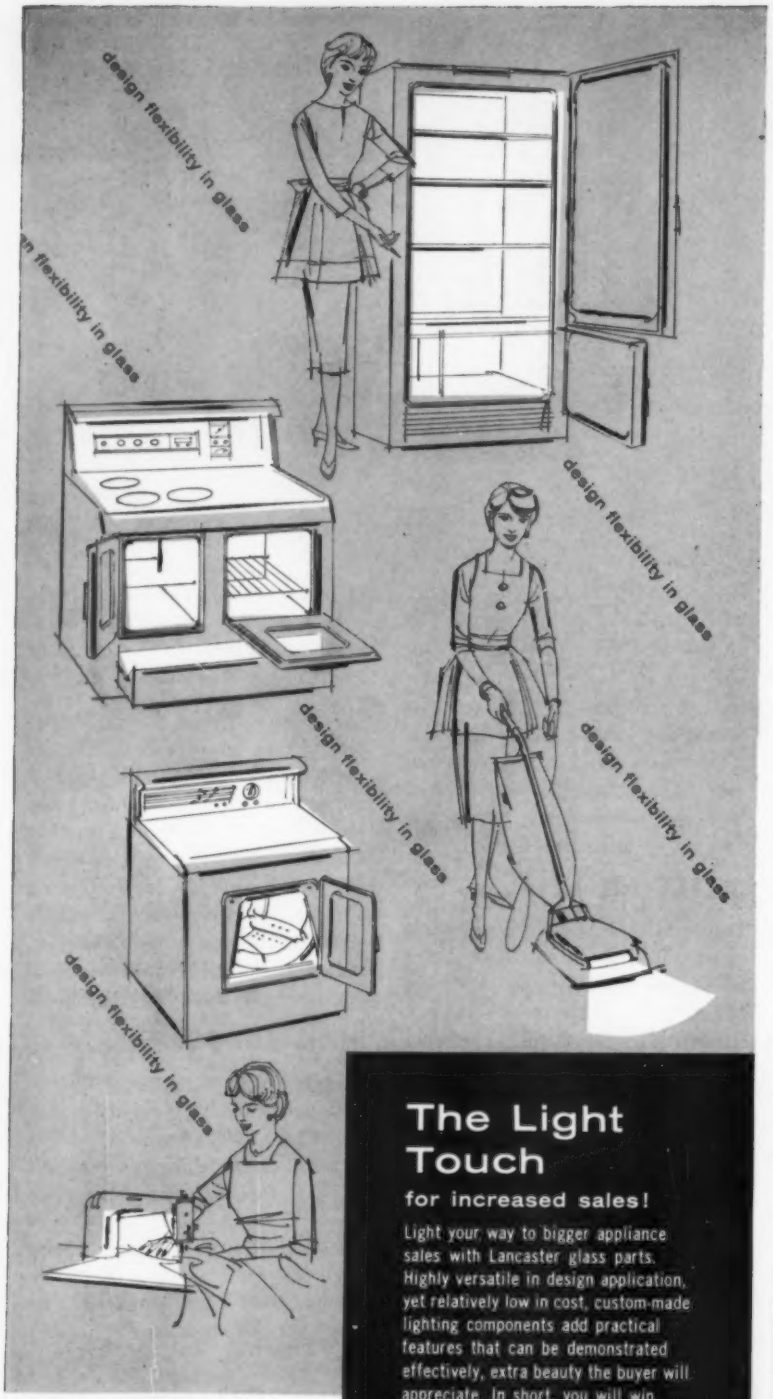
Send for NEW

DODGE PRODUCTS BULLETIN

This new 8-page Dodge Products Division bulletin is a "must" for those interested in securing the services of a complete manufacturing organization. It tells you how you can benefit by the research, development, and manufacturing facilities of this specialized division of Dodge Steel Company. The diverse engineering and production services—*from idea to finished product*—are described. Typical products, ranging from small machined, heat-treated components to large and complex special equipment, are shown.

Among the numerous facilities covered are milling and drilling, turning, testing and drafting, boring, welding, additive finishes, jigs and fixtures, etc. Send for your *free copy* today! Ask for Bulletin 658.

For more information, turn to Reader Service card, circle No. 445


design flexibility in glass
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design flexibility in glass

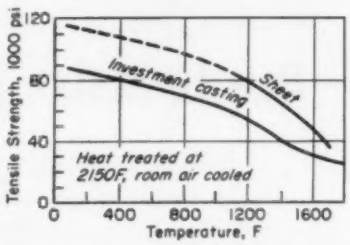
Lancaster®
glass and plastics
to brighten your product's future

The Light Touch
for increased sales!

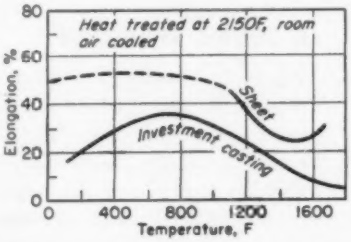
Light your way to bigger appliance sales with Lancaster glass parts. Highly versatile in design application, yet relatively low in cost, custom-made lighting components add practical features that can be demonstrated effectively, extra beauty the buyer will appreciate. In short, you will win friends and influence prospects at the vital point-of-sale.
Our lighting engineers can help you create new product applications, assist you with special assembly, optical or engineering problems. Put this expert knowledge to work for you, write Lancaster Glass Corporation, Lancaster, Ohio, or call OLive 3-0311.

For more information, turn to Reader Service card, circle No. 431

What's new IN MATERIALS



***Tensile strength** of sheet and investment casting made of newly developed nickel-base alloy.*



***Elongation** of sheet and investment casting made of Hastelloy N.*

investment castings.

The nickel-base alloy has good oxidation resistance in air and shows promise for continuous use at temperatures up to 1800 F. Intermittent use at temperatures up to 1900 F may also be possible, depending on other conditions.

Alloy N has good weldability and can be readily forged, according to the producer. The hot working range is between 1600 and 2150 F. The alloy has been extruded and produced in the form of seamless and welded tubing.

New Silane Improves Plastics Laminates

An amino-functional silane has been developed that reacts with both organic and inorganic materials to unite them in a strong, durable bond. The silane, when used as a coupling agent between glass cloth and organic resins in phenolic, epoxy and melamine laminates, improves the flexural and compressive strengths of the laminates, and reduces the effect of water on physical and dielectric properties. The new product, called Z-6020, is now com-

(Advertisement)

VINYL-METAL LAMINATES IN DESIGN

CLAD REX

The broad effect of CLAD-REX® on industrial design, engineering, and selection of materials

Reaction to the potential offered by vinyl-clad metals is contradictory. The potential advantage is so broad that it's hard to believe. But, when full realization does begin to develop, enthusiasm tends to go too far!

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

Clad-Rex is a vinyl-metal laminate. Specifically, a calendered, semi-rigid poly-vinyl chloride film bonded to sheet metal. All alloys and tempers of aluminum and steel (including galvanized and aluminized) are commonly used. However, other metals can be used where their special properties are important to end product performance.

The sales appeal of Clad-Rex vinyl-metal laminate

The words *calendered* and *film* mean styling in Clad-Rex is unlimited, because film can be printed. Simulated wood-grains and leathers, as well as any color, combination of colors, texture or pattern can be used. Or you can design your own, if you prefer.

This unlimited choice ranges from sparkling burnishes including high metallics, to non-reflective matte finishes (or variations between) as well.

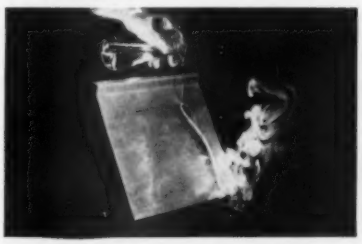
The abrasion resistance of Clad-Rex vinyl-metal laminates

The words *semi-rigid* and *poly-vinyl chloride film* mean Clad-Rex has unusual resistance to abrasion. Therefore, products made of Clad-Rex are more durable and suited to usage where abrasion resistance is required.

However—most important to manufacturing—Clad-Rex can be processed without the careful handling or rejects common to other pre-finished metals. This advantage in itself results in a substantial saving in cost. Even the finishing of *un*finished metals leads to a reject factor that becomes a savings when Clad-Rex is used.

The corrosion resistance of Clad-Rex vinyl-metal laminates

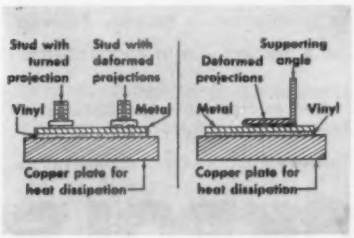
The words *poly-vinyl* and *chloride* become important again, because of the inherent properties of the Clad-Rex vinyl. It provides excellent resistance to acids and alkalis, as well as other corrosive chemicals. It also has high dielectric properties.



The fabrication of Clad-Rex vinyl-metal laminates

Clad-Rex can be formed in almost as many ways as any *un*finished sheet metal—including deep drawing!

Resistance welding, generally, is limited to projection techniques.



However, the resistance welding equipment must be (1) tooled for series welding procedures (both electrodes on same side of sheet), and (2) capable of very short weld times with extremely fast follow-up of forging pressure.

Epoxy resins are proving quite successful for assembly. Clamps can be eliminated by using resistance weld tacking or interlocking design.

The cost advantage of Clad-Rex vinyl-metal laminates

As a purchased material going into a user's plant, vinyl-metal laminates cost more than *un*finished or some other pre-finished metals. *But, most important, end products made of Clad-Rex generally cost less!*

The reasons are worthy of close examination:

(1) Parts made of Clad-Rex require no further finishing. This is a savings in equipment, finishing material, factory floor space, labor, handling, etc.

(2) The abrasion resistance of Clad-Rex substantially reduces (and often eliminates) rejects. This includes both rejected products *and* the expensive handling, reworking activities, and labor required.

The broad effect of Clad-Rex vinyl-metal laminates on manufacturing literally simplifies your processing operations. Movement of sub-assemblies, etc., through your plant actually becomes more direct—out of your dies into assembly!

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. Free of charge, a Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product. **Clad-Rex Division of Simoniz Company, 2109 Indiana Avenue, Chicago 16, Illinois. Telephone: VIctory 2-7272.**

For more information, turn to Reader Service card, circle No. 470

* DON'T OVERLOOK CARBON/GRAPHITE!

No Other Material Can Do ANY of These:

★ Withstand immersion in water from 4,000°F without cracking.

★ Resist surface atmospheric action while retaining constant and reproducible contact resistance.

★ Be readily processed to provide low friction (graphite) or high friction (carbon) or any desired intermediate value.

★ Withstand electric arcing in contacts, lightning arresters and similar applications without appreciable dimensional changes.

★ Serve as an electrical conductor which is readily machinable and can operate satisfactorily up to 6,000°F.

No Other Material Can Do ALL of These:

★ Resist corrosive action of most gases and chemicals.

★ Serve as a semi-permanent, readily-formed mold for casting metals or glass.

★ Act as a seal ring around a moving shaft to retain liquids and gases.

★ Operate as a sliding contact on commutators and slip rings.

★ Serve as a bearing material for vacuum applications or as an insert in ordinary bearings.

★ Operate as a friction unit in constant-speed clutches.

★ Serve as a non-welding contact, either by itself or in combination with other metals.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE

"EVERYTHING IN CARBON BUT DIAMONDS"

SEAL RINGS • BEARINGS • ROCKET NOZZLES • ELECTROCHEMICAL CELL ANODES • FLUXING TUBES • BRAZING BOATS & TRAYS • CATHODIC PROTECTION ANODES • RISER RODS • VOLTAGE REGULATOR DISCS • ELECTRICAL CONTACTS • HEATING ELEMENTS & ELECTRODES • TUBE ANODES • BRAZING TIPS • RUN-OUT TABLE SLABS • MOTOR & GENERATOR BRUSHES • FRICTION SEGMENTS • PUMP VANES • POROUS CARBON . . . and many more.

For more information, turn to Reader Service card, circle No. 412

EFFECT OF Z-6020 ON PHENOLIC-GLASS LAMINATES

Type →	Modified[a]	Unmodified
Flex Str, psi		
Dry	75,000	66,000
Wet	74,000	44,000
Compr Str, psi		
Dry	64,000	24,000
Wet	57,000	5,000
Dielec Str (in oil), v/mil	310	310
Dielec Const (1 mc)		
Cond A	5.7	5.1
Cond D48/50	5.8	16.2
Dissip Factor (1 mc)		
Cond A	0.021	0.012
Cond D48/50	0.021	0.440
Surface Res, ohms		
Cond A	4×10^{12}	4×10^{12}
Cond C96/35/90	0.1×10^{12}	$<10^{7}$
Vol Res, ohm-cm		
Cond A	7×10^{12}	40×10^{12}
Cond C96/35/90	0.5×10^{12}	$<10^{7}$
Arc Res, sec	120	Variable

[a]Phenolic-glass laminate modified with 0.1% Z-6020 silane in the resin.

mercially available from Dow Corning Corp., Midland, Mich.

Other uses

Glass insulation—Added to the organic resins used as binders for glass and mineral wool insulation, Z-6020 acts as a coupling agent between the resin and the glass or mineral wool. It improves the water resistance, resiliency and heat resistance of the insulation, according to Dow Corning.

Dyeing aid—Glass fibers can be dyed with many common wool dyes if they are first treated with Z-6020.

Epoxy curing agent—The silane can be used as a curing agent and as a diluent for epoxy resins.

Dispersing agent—Many materials can be dispersed more easily in water if they are first slurried in an aqueous solution of the silane.

The producer warns that Z-6020,

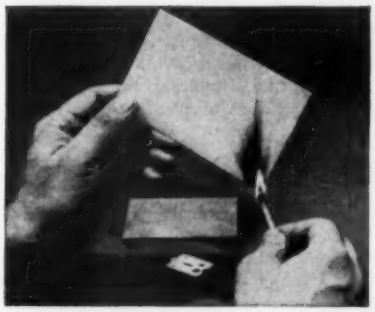
M/DE ON MICROFILM

Back volumes of this magazine are now available on microfilm. Volumes under our earlier names, *Metals & Alloys* and *Materials & Methods*, are included. Sales are restricted to those subscribing to the current paper edition. Please address inquiries to University Microfilms, 313 N. First St., Ann Arbor, Mich.

PROGRESS IN PLASTICS

NEW FLAME-RETARDANT EPOXY LAMINATES OFFER HIGH STRENGTH-WEIGHT RATIO, LOW LOSS

Much is being said lately about the fabulous epoxies. No better use, however, has been made of these remarkable resins than the development by CDF of new improved laminates for electrical-insulating purposes.



New CDF epoxy Dilecto laminate exhibits flame-retardancy in simple match test.

CDF epoxy Dilecto® laminates, made with either treated glass-cloth or cellulose-paper base, combine the highest strength-to-weight ratio and the highest impact strength with low water-absorption, low loss properties, and improved machinability. The new epoxy Di-Clad® laminates for printed-circuit use also display exceptional foil-bonding strength, high hot-solder-resistance, and higher maximum operating temperatures than previously obtainable in standard laminates.

And now permanent flame-retardancy and excellent arc-resistance are added to many grades of epoxy laminates from CDF, both GB and XXXP. These laminates, known as the EFR series, meet NEMA G-11 and MIL-P-18177B, Type GEB. This combination of properties should further widen the range of applications for this superior insulating material. CDF Technical Bulletin 11200 describes epoxy Dilecto and Di-Clad laminates in detail.

CDF SILICONE-RUBBER TAPES INSULATE ELECTRO-FLEX HEATERS

Vulcanized "sandwiches" of uncured CDF silicone-rubber tape around patterns of resistance wire—that's what new Electro-Flex heaters are made of.

Electro-Flex, a CDF customer, makes these heaters for pipes and valves in the fuel systems of all U.S. missiles and rockets. They're used also as storage-drum heaters, crystal-oven heaters, and heat-sealing units.

The standard Electro-Flex heater, which is actually comparable to a miniature electric blanket, consists of four plies of CDF silicone-rubber tape (woven glass-fiber cloth with uncured silicone-rubber calendered on). Each ply is .010-inch thick. Other Electro-Flex heaters are designed particularly for flexibility or for thinness where the application so warrants. New uses for these tiny temperature-control devices are being uncovered every day. CDF supplies Electro-Flex with 80% of its silicone-tape requirements. Full information on CDF silicone-rubber tapes is available in Bulletin SR-3.

SKIVED TAPES OF UNSUPPORTED TEFLON

Four new grades of tape, made of skived duPont "Teflon" TFE fluorocarbon resin, are now available from

CDF. Excellent electrical properties, resistance of all common chemicals, and a low coefficient of friction characterize these new tapes, designed primarily for high-temperature and high-frequency wire and cable insulation. However, they may be used also as stock from which gaskets, seals, and miscellaneous small parts can be cut.

CDF tapes of Teflon range in width from ¼" to 12" in ⅛" increments, in thickness from .002" to .100". Request Technical Bulletin 97.

NEW CDF LITERATURE • *Bulletins referred to in this advertisement may be obtained from your CDF representative, or you may send the coupon below, indicating the Bulletins you want.*

Please send me the following Technical Bulletin(s):

- ☐ Bulletin 11200—CDF epoxy Dilecto and Di-Clad laminates
- ☐ Bulletin SR-3—CDF Silicone Rubber Tapes
- ☐ Bulletin 97—CDF skived Teflon tapes

Name_____ Title_____

Company_____

Street Address_____

City_____ Zone_____ State_____

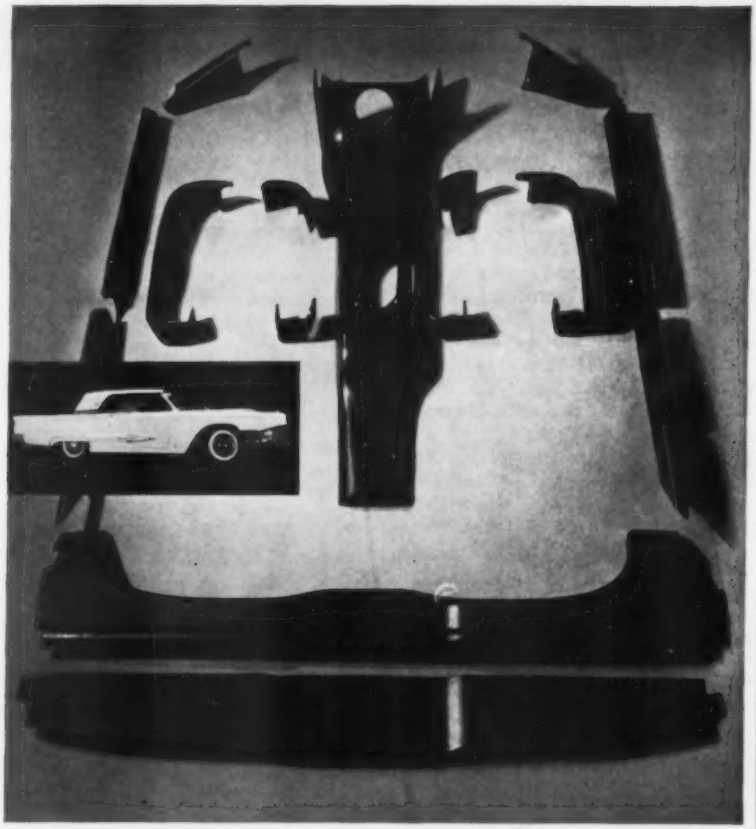
CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 25, DEL.

In Canada: 46 Hollinger Road, Toronto 16, Ontario

For more information, turn to Reader Service card, circle No. 511

Thunderbird interior high-styled with Colovin vinyl-on-steel laminate



For second year, Ford specifies Colovin over other vinyl-coated materials to create luxurious leather texture and exact color match

Door panels, window mouldings, instrument panel extensions, package tray, bucket seat mouldings, control "console" — the entire interior of the '59 Thunderbird presents an uninterrupted flow of luxurious leather-grained vinyl.

To achieve this effect, Ford subjected a number of materials to rigid testing. Only Colovin filled Styling's requirements of deep-texture embossing and exact color matching of upholstery, laminated parts and painted surfaces.

Colovin laminate also met every Engineering specification. It is machined to precise tolerances on standard equipment. It requires no finishing, painting or costly hand operations. In stamping, the vinyl surface acts as a natural lubricant.

Get the whole story in "Colovin Meets Metal." Laminate samples, colors and textures, test specifications, industrial applications, and a list of laminators to whom we supply Colovin vinyl sheeting. Mail coupon for copy.

COLOVIN®

first and finest in vinyl laminate

COLUMBUS COATED FABRICS CORP., Dept. MD-859, Columbus 16, Ohio

Please send me your brochure, "Colovin Meets Metal."

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 370

What's new IN MATERIALS

like other strong amines, can cause serious permanent damage to the eyes. It may also cause irritation if splashed on the skin.

3200 F Refractory Handles Like Plastic

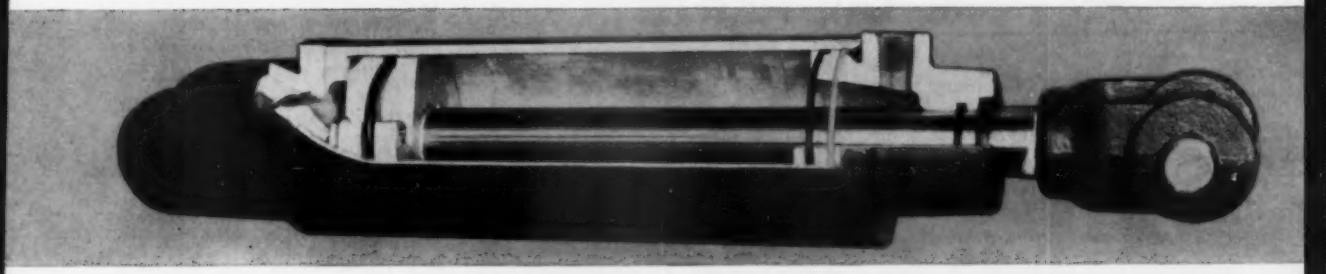
H. K. Porter Co., Inc., Refractories Div., Porter Bldg., Pittsburgh 19 has introduced an 80% alumina-plastics refractory material called Pitco 80. The material is said to combine all of the advantages of monolithic construction, formerly available only in castable and ramming mixes, with the advantages of plastics construc-

Making ductile iron — More efficient production of ductile iron is now achieved with a new high magnesium-silicon alloy developed by Union Carbide Metals Co., Div. of Union Carbide Corp., 535 5th Ave., New York 17. The alloy, when used with a new technique known as "plunging" (shown here), yields magnesium recoveries of up to 50%. This is said to be about twice as much magnesium as can be recovered by the conventional open-ladle treatment where more dilute magnesium alloys must be used. The magnesium alloy, called EM 55, is placed in a refractory basket and plunged into a ladle of molten iron. The magnesium vaporizes and bubbles up through the metal. Enroute the magnesium is absorbed by the iron, giving ductile iron the composition needed for its special properties.

There's a HOLE lot of sense in this use of mechanical tubing

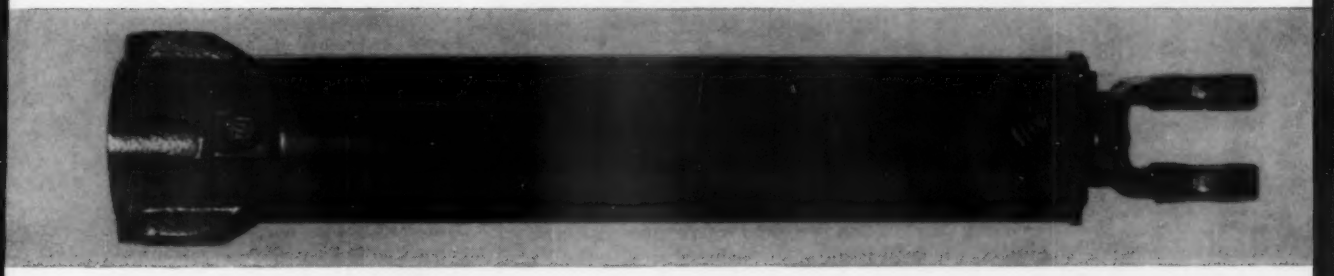
What we're talking about is USS Shelby Seamless Mechanical Tubing. Here's how Industrial Hydraulics Division, Cessna Aircraft Company uses it to boost life, simplify manufacture and lower costs in the hydraulic cylinders they supply to agricultural equipment builders. We quote from their letter to us:

"The cut-away cylinder is a unit we furnish to one of our many customers. This is a 3½" diameter, double-action cylinder used for mounting on pull-behind tools



such as plows, cultivators, and disc harrows. This cylinder uses your Shelby Seamless Mechanical Tubing with the I.D. bored to size and roller burnished to a finish of approximately six to eight RMS. The expected life of this cylinder is in excess of 300,000 cycles, operating at 1,500 psi hydraulic pressure.

"The other cylinder is furnished to another one of our customers, and is a 3¼" I.D. double-action cylinder with a 13" stroke. Used to raise and lower the platform of their self-propelled combine, it is similar to the cut-away cylinder



with respect to finish requirements and material for the barrel. The operating pressure is approximately the same and so is the expected service life of five years, or 300,000 cycles. Generally these cylinders may be serviced for additional use by merely replacing the seals.

"The severe field conditions these cylinders are subjected to are some of the most extreme to which cylinders could be exposed."

In critical mechanical applications like these, and in an almost endless number of fabrications that are essentially tubular in character, Shelby Seamless will ensure improved performance, finer appearance and economical production.

For Shelby Seamless offers more than just a pre-bored hole. It not only combines to an exceptional degree the qualities of strength, uniformity and dimensional accuracy but, in addition, is readily workable and has excellent machining properties. If you want to find out how it can be most effectively applied to your designs, contact your nearby Shelby Distributor.

And remember—USS Shelby Tubing is made by the world's largest and most experienced manufacturer of tubular products.

USS and Shelby are registered trademarks

National Tube Division of USS United States Steel

For more information, circle No. 430

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division • United States Steel Export Company, New York

NEWS
from Torrington on
SMALL PRECISION METAL PARTS

"Custom manufacture" has many meanings to the Specialties engineers here at Torrington. One of our customers, for example, may require a part having fairly wide tolerances of several thousandths. The very next job on an engineer's desk may present a real challenge, calling for a complex series of manufacturing operations and a precision measured in ten-thousandths. Torrington's unmatched experience, engineering skills and facilities are ready to serve you *whatever* your particular requirements might be.

A comparatively simple job now going through calls for train axles for HO gage model equipment. The length tolerance is held to .010" and the diameter tolerance is .002". Our engineers complete the whole operation on super high-speed blanking machines designed by Torrington which operate at much greater speeds than available with other commercial equipment. Result . . . substantial savings on a low-cost, high-volume item for our customer.

In contrast to this, a current contract with one of America's leading clockmakers calls for a balance shaft with a diameter tolerance of .0005". If the shaft is supported at the points and rotated, the OD must rise and fall a maximum of .0015" during one revolution. Specialties engineers meet these more demanding specifications with a machine that will cut, form and mill in a single high-speed operation perfected by Torrington. Usual expensive burnishing is replaced by a much faster and far less expensive method to produce a fine finish. Result . . . another example of our ability to adopt new methods in solving a customer's problem economically.

A special engineering department is maintained by the Specialties Division to help you solve any problems involving small metal parts. If required, our highly experienced and skilled engineers will help you design the part for most efficient and economical production. More and more manufacturers are turning to specialized Torrington service. If small precision metal parts are *your* problem, just circle our number on the reply card, call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 777 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

For more information, turn to Reader Service card, circle No. 385

tion. Outstanding characteristics of the new material are:

1. It withstands temperatures up to 3200 F.
2. It is air and gas tight.
3. It has good thermal shock resistance.
4. It is easy to install.
5. It withstands heavy loads.

The alumina-plastics refractory is expected to be used as a lining material in aluminum reverberatory and electric furnaces. Other expected uses: burner blocks, desulfurizing forehearths, holding ladles and boiler target walls.

Other News . . .

Metals

▸ Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30 has announced that its alloy steel "Jalloy" is now available in four hardness ranges. Copper has also been added to the alloy to provide additional resistance to atmospheric corrosion.

▸ Low cost, light-wall stainless steel fittings and flanges designed for nominal temperature, low pressure, noncritical process piping have been introduced by Tube Turns Div., Chemetron Corp., 2929 Magazine St., Louisville 11, Ky. The new line, called Pipe-Mate, is available in sizes from ½ to 4 in.

▸ Eight bars of ferrous materials, whose oxygen and nitrogen content have been precisely determined, comprise a new type of standard sample now available from Standard Sample Clerk, National Bureau of Standards, Dept. of Commerce, Washington 25, D. C. The fee is $10 per sample.

▸ New porous metal filter disks, constructed completely of stainless steel fibers, have been introduced by Purolator Products, Inc., Rahway, N. J. The disks measure 1/16 in. thick x 10 in. o.d. x 3 in. i.d.

Nonmetallics

▸ Laminac 4104 is the name given to a new polyester resin designed for use in glass-reinforced plastics parts operating at temperatures up to 400 F. The resin, suitable for such applications as aircraft heating ducts, is available from American Cyanamid Co., Plastics and Resins

"Customeered" components basic to industry

ideas on "Customeered" RUBBER PARTS

...their design and application for improved product performance **No. 1**

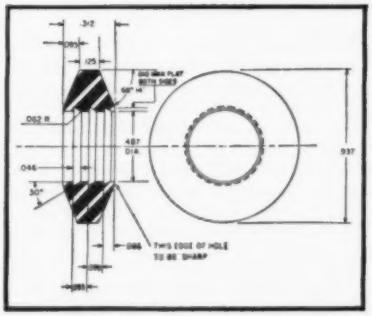
New ORCO continuous process now custom molds precision rubber parts in volume—at less cost!

Precise tolerances within ±0.003 in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

Greater precision, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

Direct feeding, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.

Wide range of parts being more economically produced through Ohio Rubber's new molding process include (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These, like all the many other small, precision parts already produced or being produced, vary in dimensions up to 1½" in diameter and 1" in thickness.



High-precision is indicated in the close tolerances of this quadruple-landed seal for auto shock absorbers—more economically produced in volume through Ohio Rubber's new high-speed, continuous molding process.

Large volume production results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

Complete information on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customeering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

9DE1

THE OHIO RUBBER COMPANY

WILLOUGHBY, OHIO

A DIVISION OF THE EAGLE-PICHER COMPANY

For more information, turn to Reader Service card, circle No. 454

Steel Service Centers throughout the country have built up their inventories in anticipation of a suspension in steel production. These stockpiles totaling almost 3,600,000 tons are valued at ¾ billion dollars. If you have been using a steel service center as your source of supply—you can thank your lucky stars—because chances are they will still be able to fill your requirements.

Each distributor's representative is a metal specialist and is qualified to assist you with application and supply problems.

MICROROLD STAINLESS STEEL is regularly carried in stock in 252 of these independent steel warehouses. Washington Steel is a producer of sheet and strip exclusively, all of which is precision rolled on Sendzimir mills.

WASHINGTON STEEL CORPORATION

8-F Woodland Avenue, Washington, Pa.

For more information, turn to Reader Service card, circle No. 479

Div., 30 Rockefeller Plaza, New York 20.

▸ A specially compounded thermosetting plastic resin is said to effectively seal pores in powdered metal parts. The resin, called Sinter-Seal, withstands temperatures up to 400 F, and has good resistance to plating solutions, moisture and oil. It is available from National Sinter-Seal Co., 609 Seneca Industrial Center, Buffalo 10, N. Y.

▸ A new grade of laminated plastic made from glass cloth impregnated with TFE resin is available from Continental-Diamond Fibre Corp., Newark 107, Del. The material, known as Dilecto GB-108TED, is designed for corrosive applications such as gaskets and seals, and for flexible electrical insulation such as radar windows and printed circuits.

▸ A vibration dampening material, composed of asbestos fibers bonded with chlorinated rubber, is available in sample quantities from Armstrong Cork Co., Industrial Div., Lancaster, Pa. The material, designated No. 881-658FF, is recommended for use in applications requiring high damping efficiency at moderately high temperatures.

▸ Development of a new acrylic-type themoplastic resin has been announced by J. T. Baker Chemical Co., Phillipsburg, N. J. The resin, designated PL-12, has a heat distortion point of 240 F, a flexural modulus of 415,000 psi and a notched Izod impact strength of 1 ft-lb per in.

Finishes

▸ Development of a new solvent or alkali removable coating for in-shop protection of metallic and nonmetallic surfaces during storage, forming and fabricating operations has been announced by Turco Products, Inc., 6135 S. Central Ave., Los Angeles 1, Calif. The product, called Fabrifilm, is moisture and corrosion resistant.

▸ An organic-ceramic coating called L-154 has been developed by Dyna-Therm Chemical Corp., 3813 Hoke Ave., Culver City, Calif. for use at high temperatures. The new coating can be applied by conventional spray equipment. The producer says no enameling or atmospheric curing ovens are required.

▸ Rigid or flexible glass-like coatings on metallic and nonmetallic materials can be obtained by using a new polyurethane coating called Poly-Form. The dried coating is said to have good resistance to heat, abra-

Aluminum or zinc clad steel by production metallizing

- *any shape or size*
- *unlimited thickness*
- *no heat distortion*

Modern metallizing provides the product engineer with an extremely flexible, practical method of producing aluminum or zinc clad steel parts. High speed, automated metal spray equipment applies these coatings to practically unlimited thicknesses on any shape or size part without heat distortion.

a typical example

problem: **provide uniform heat distribution on thin steel shell**

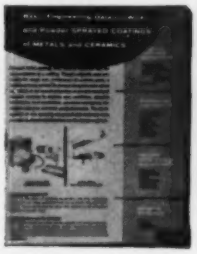
The excellent sanitary qualities of stainless steel make it an extremely desirable material for cooking utensils. But with the comparatively thin, drawn shells (.020" to .050"—varying by manufacturer), uniform distribution of heat presents a problem.

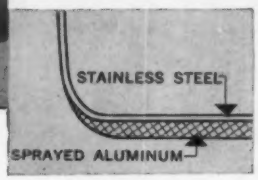
The solution is being provided for a number of high-volume manufacturers by metallized aluminum. Surface preparation is by grit-blasting as the shells rotate on a spindle. Metco Aluminum is then sprayed on the bottom, with automated traverse equipment, to closely controlled thicknesses (from .040" to .120", depending on the particular utensil and its manufacturer). The sprayed aluminum is carried up the sides beyond the radius and is tapered off according to individual design.

This is but one of many solutions to fabrication problems offered by sprayed metals to design engineers. In addition to the aluminum example given, zinc is also commonly used for corrosion-proofing in many production applications, such as steel capacitor cases, refrigerator parts, pole line hardware, etc. Sprayed zinc is also used to replace coatings burned, threaded, or machined off during fabrication.

For a round-up of some typical applications and engineering data on the characteristics of metallized coatings, write for Bulletin No. 136-A.

FREE BULLETIN ▶





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In Great Britain:
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

Mr. Donald A. Watson
Metallizing Engineering Co., Inc.
1175 Prospect Avenue, Westbury, Long Island, New York

Please send me ☐ Bulletin 136-A

Name Title

Company

Address City State

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You machine better and faster with

SHENANGO CAST BAR STOCK

Because Shenango tubular stock is *centrifugally* cast, impurities and pockets are *forced* out of the metal in the molten stage. Moreover the grain is finer, pressure-dense and more uniform. This results in smoother machining, better control, and less waste of time and metal.

Made of high-strength Meehanite metal or long-lasting bronze, Shenango tubular stock comes in a *complete* range of I.D. and O.D. sizes. Its lengths go up to 20 feet, depending on diameter, which keeps cut-off waste to a minimum.

While the demand for Shenango bar stock is largely tubular . . . solid round, square, hexagonal, rectangular and other special shapes are readily available.

It will pay you to specify Shenango bar stock for longer wear, greater strength, fewer rejects . . . and lower over-all cost. For full information, write to: *The Centrifugally Cast Products Division* of The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

For more information, turn to Reader Service card, circle No. 404

What's new IN MATERIALS

sion, marine corrosion, sun, chemicals and moisture. The coating is available from Poly-Form Mfg. Co., P. O. Box 305, Escondido, Calif.

▸ Allied Research Products, Inc., 4004 E. Monument St., Baltimore 3, Md. has introduced Isobrite 623 Copper Addition Agent for semi-bright buff, cyanide copper plating solutions. It can be used in plating steel, zinc, brass and bronze parts.

▸ A new alkyd baking enamel with high metallic content has been introduced under the trade name StaR-Mite by Rinshed-Mason Co., Milford at Epworth, Detroit 10. The paint is recommended for use on automobiles, outboard motors, metal furniture, office equipment and appliances.

▸ Orosen 999 is a 24-carat, acid, bright gold solution that produces hard, ductile mirror-bright electroplates in either tank or barrel plating. The product contains no silver, antimony or sulfur compounds, and has good resistance to tarnishing. It is available from Technic, Inc., P. O. Box 965, Providence, R. I.

▸ Water-based, ready mixed aluminum-pigmented paints of exceptionally high luster have been made possible by a new process for incorporating aluminum pigments into aqueous systems. The process was developed by Metals Disintegrating Co., P. O. Box 290, Elizabeth, N. J.

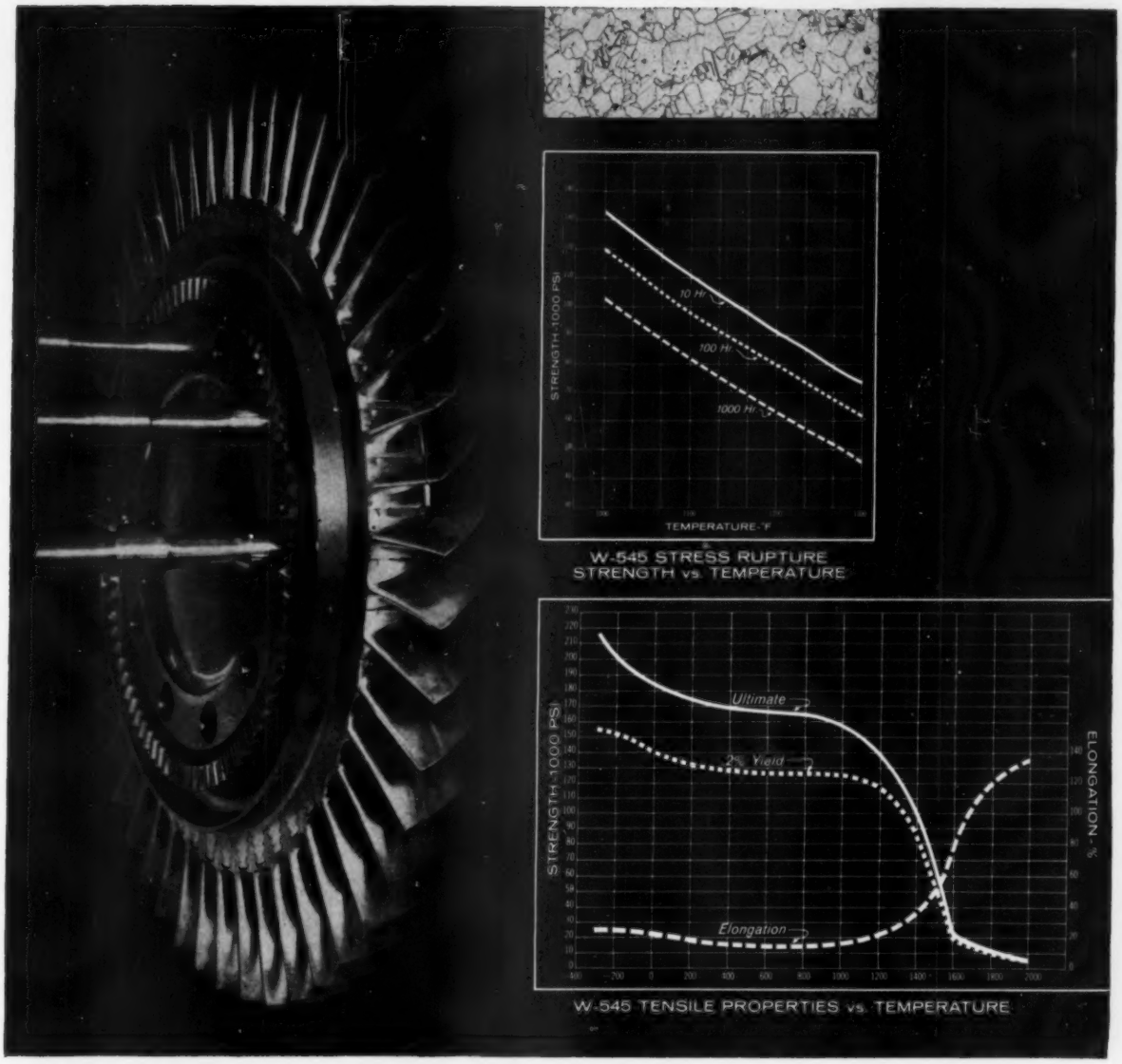
Joining materials

▸ A high nickel brazing alloy for high temperature service is available from Wall Colmonoy Corp., Stainless Processing Div., 19345 John R St., Detroit 3. The alloy, called Nicrobraz No. 160, has a hardness of 35-40 Rockwell C before brazing; it is said to be the softest of all nickel-base brazing alloys.

▸ Heat and corrosion resistant welds on nickel alloys, stainless steel and low alloy steels are produced by a new welding electrode called NiTectic 222. The electrode, available in 3/32, 1/8, 5/32 and 3/16-in. dia, was developed by Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N. Y.

Testing equipment

▸ A new, high temperature, vacuum tensile testing furnace for operation at 4500 F has been developed by Richard D. Brew & Co., Inc., Vacuum Furnace Div., Airport Rd., Concord, N. H. The unit can be adapted to virtually all tensile testing equipment, according to the developer.



NEW HIGH-TEMPERATURE ALLOY W-545 HAS 20% MORE STRENGTH

Twenty percent more strength at 1200°F from this turbine disc gave added dependability for a Westinghouse customer using W-545. This new high-temperature alloy will withstand higher stress levels than similar alloys at the same operating temperatures . . . or it will withstand equivalent stress characteristics at 100°F higher operating temperatures.

Critical high-temperature parts can be made from this material that have excellent strength-to-weight ratios and can be used at temperatures up to 1350°F . . . excellent characteristics at −300°F.

W-545 has proven itself superior for turbine wheels . . . compressor discs and shafts . . . combustion chambers . . . housings and skin materials. W-545 is nonmagnetic and has a low strategic alloy content, permitting ease of fabrication for fasteners . . . rings . . . spacers . . . fittings . . . brackets . . . supports and mounts.

The Westinghouse Metals Plant can furnish strip, sheet, bar, forgings and forging stock in W-545 and other wrought high-temperature alloys. Get all the information today; write: Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pennsylvania.

J-05010

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

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LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

Only IRIDITE®

Process Engineered

Chromate Conversion Coatings

Give you 5 additional benefits for Corrosion Protection—Paint Base—Decorative Finishing

1 A COMPLETE PROCESS ENGINEERED LINE

Developed for specific applications, there is an Iridite to provide the finish you desire, fit the equipment you have available and give the performance you require. Most Iridite coatings meet rigid military and civilian specifications.

2 EXPERIENCED TECHNICAL SERVICE

Our large field engineering staff is thoroughly familiar with chromate conversion coatings and related finishing operations. They'll help you check every step in your finishing operation to make sure you're getting the best possible finish on your products.

3 PRODUCT AVAILABILITY

Warehouses located in strategic industrial areas enable us to provide you with fast, economical delivery on any Iridite.

4 ECONOMY

The superior performance of Iridite provides low final cost by extending operating life and lowering maintenance costs. In addition, Iridite gives you a finish that adds considerably to the value of your product. There's an Iridite to meet every cost and performance requirement.

5 RESEARCH AND DEVELOPMENT FACILITIES

If you have an unusual application, we will gladly work with you. Our entire staff of experienced engineers and chemists, and our completely equipped facilities are at your service.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Apply by dip, brush or spray methods — at room temperature — manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel required.

If you are using chromate conversion coatings to finish zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze — consider the above benefits of Iridite. For complete information, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILE.

Allied Research Products, Inc.

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BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings | IRILAC™ Clear Coatings | ISOBRITE® Plating Brighteners | ARP® Chemicals & Supplies | WAGNER Line of Equipment

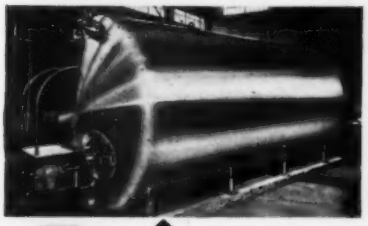
For more information, turn to Reader Service card, circle No. 456

O.E.M.... A-P-C's at Your Command with Facilities for the Finest Craftication* in Stainless Steel

**Craftication means the fine craftsmanship typical of A-P-C*

There's virtually nothing too small — nothing too large — nothing too complex:

- in deep, unbelievably deep draws from a single sheet
- in heli-arc, automatic weldments
- in skillful manual welding
- in fine, close tolerance machining
- in highly polished, mirror-like finishing
- in practically any fabricated stainless steel component, or end product



Stainless Steel Refrigerated and non-refrigerated storage tanks up to 20,000 gal. capacity.

Deep (24") draw from one sheet with 3 diameters at rim.

Formed and welded spiralled tube.

Tubular heater

Large tubular manifold for submarine

And our facilities are so versatile we're glad to make ONE PIECE OR A MILLION! Just a postcard will bring you our new facilities catalog — promptly. **Write today.**

ALLOY PRODUCTS CORP.
1070 Perkins Avenue
WAUKESHA, WISCONSIN

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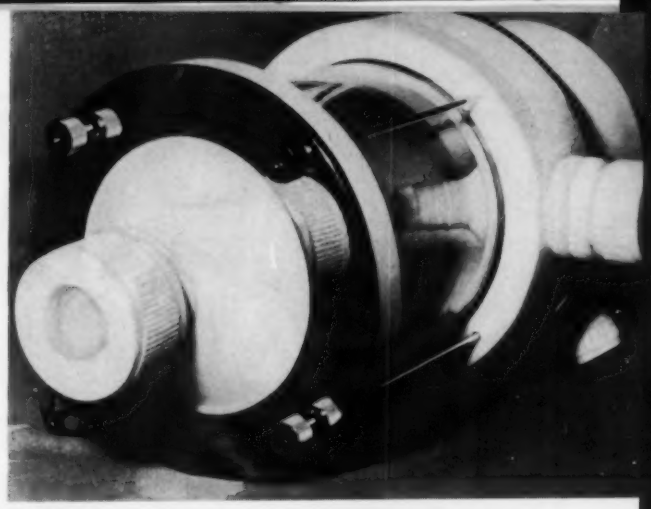
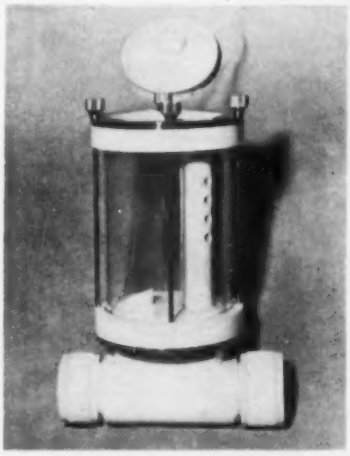
MATERIALS AT WORK

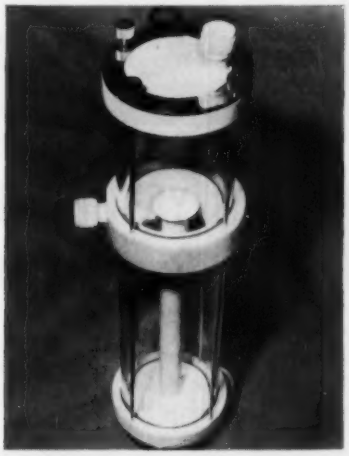
Teflon— cont'd from p 12



***Blood reservoir** made from a molded Teflon rod.*



***Second blood reservoir,** also made from single piece of molded Teflon rod, acts as a settling chamber for blood before it is oxygenated.*



***Sump suction reservoir** feeds the blood from patient's heart to reservoirs. End plates, interior valve and threaded tube leads are Teflon.*

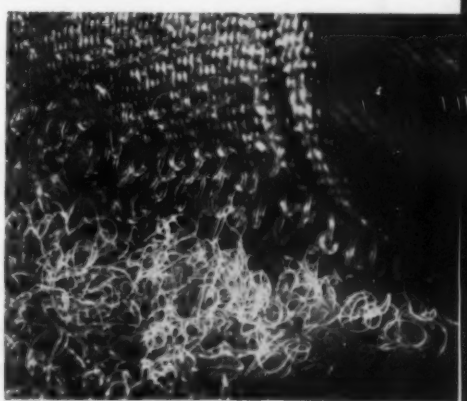
even stopped of beating.

According to Raybestos Manhattan, Inc., supplier of the Teflon, all parts were milled, machined, bored and hand-formed from single pieces of molded bar and rod stock. The parts were fabricated by B & B Mfg. Co.

Tiny Nylon Hooks Make Unusual Closure

What appears in the photo at the right to be a tangled mess of hooks and threads is actually what is probably the most unique closure to come along since the invention of the zipper. Already replacing the zipper in many clothing applications, the new closure has great potential for a wide range of industrial applications.

The closure, which its inventor says was suggested to him when he became entangled in a burr patch, consists of two strips of woven nylon tape. One of the strips, called the hook or male section, is covered with a myriad of tiny, stiff nylon



Foaming begins in a seat cushion mold for a 1959 automobile

POLYETHER URETHANE FOAM
. . . from Reynolds Chemical, of course!

Next time, specify polyether urethane foam for *molded* cushioning. Coring is available, optionally, at Reynolds Chemical Products Company.

Perfectly cored automobile seat cushion emerges from squeeze rolls

REYNOFOAM* EQUALS OR EXCELS FOAM RUBBER IN:

Price · Weight · Tensile Strength · Cleanability
Fire Resistance · Dimensional Stability · Aging
Compression-Deflection Characteristics

It won't crumble, shrugs off exposure to light and air. Densities range from 1½ lb. per cu. ft. up to 12 lbs. or more; shrinkage is closely controlled.

Reynolds can deliver *commercial quantities* to your exact specifications. Write to Reynolds for information on the expert technical assistance available to help solve your application problems.

* Reg. trademark

Reynolds Can Mold It — If Anyone Can!

REYNOLDS CHEMICAL PRODUCTS COMPANY

DIVISION OF STUBNITZ GREENE CORP. • Whitmore Lake, Michigan • Phone Hickory 9-9361

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MATERIALS AT WORK

***Blood pressure cuff** uses adjustable nylon closure.*

hooks. The other strip, the loop or female section, is covered with thousands of tiny, soft nylon loops. When the strips are pressed together, the hooks and loops engage, "creating a highly adjustable, versatile, secure, lightweight closure."

According to Velcro Sales Corp., the new fastener is the first to distribute stress over a large surface instead of at specific points or along a straight line. Nylon was selected because it is tough, durable and flexible. In addition, the nylon strips can be sewn, stapled, adhesive bonded or heat sealed. They can be washed or dry cleaned. And they can be opened and closed over 30,000 times with no loss in holding power.

The fastener is currently being tested and used in a number of applications including surgical and

***Headrest covers** are easy to fasten and easy to clean.*

At Boyertown Auto Body Works, *Youngstown Yoloy "E" Sheets are being fabricated into body sections for their commercial truck line.*

Accent on Excellence

Youngstown Yoloy "E" sheets

True value in Boyertown bodies is the trouble-free, year-in, year-out service they provide. It's a value that starts with skilled craftsmanship—using only the best raw materials available.

Boyertown Auto Body Works, Boyertown, Pa., specifies Youngstown Yoloy "E" Hot and Cold-Rolled Sheets as basic material for both the outside and inside panels, as well as for certain structural frame members such as rear corner posts and roof crowns, of their delivery truck line. They've found this versatile steel's high strength-low weight ratio allows design of higher payload vehicles.

Wherever high-strength steel becomes a part of things *you* make, the high standards of Youngstown *quality*, the personal touch in Youngstown *service* will help you create products with an "accent on excellence".

Send for free technical bulletin on Youngstown Yoloy "E" Steel.

QUALITY · YOUNGSTOWN · SERVICE

Youngstown
Youngstown, Ohio

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Carbon, Alloy and Yoloy Steel

For more information, turn to Reader Service card, circle No. 387

TESTING FOR THE SPACE AGE

Cadets at the U. S. Air Force Academy in Colorado Springs know the importance of physical testing. Intensive classroom instruction is supplemented with practical laboratory work using a total of six Tinius Olsen Universal and Torsion Testing Machines.

We are proud of the role being played by Olsen equipment at the Air Force Academy. Hundreds of other Olsen testing machines are being used to train engineers in colleges and universities throughout the country. All of these students, as well as engineers in research and industrial laboratories everywhere, know they can depend on Olsen for fast, accurate test results.

A descriptive brochure on Tinius Olsen testing equipment is yours for the asking. Write for a copy of Tinius Talks today.

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TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.
Testing and Balancing Machines

Trademark Reg. U.S. Pat. Off.

For more information, turn to Reader Service card, circle No. 388

MATERIALS AT WORK

medical equipment (see photo), packaging, filters, electronic equipment, conveyor belts, aircraft (see photo), appliances, automotive equipment and others.

Stainless Bumpers Will Not Pit, Peel

Automobile bumpers that never pit or peel may be a reality within the next couple of years, thanks to stainless steel.

Allegheny Ludlum Steel Corp. claims that various field tests conducted over a two year period indicate that stainless-clad bumpers last longer and look better than conventional chromium-plated mild steel. The test bumpers use 301 stainless clad on both sides of a mild steel base.

No information is available as to when the bumpers might actually be used, and no cost figures were given. However, automotive companies "have expressed interest in stainless-clad materials and have been investigating the use of both clad and solid stainless steel for bumpers for some time."

Glass-Epoxy Laminate Cools 'Copter Engine

Glass cloth-reinforced epoxy laminates are now being used for the contravene assembly on the new 6-ton Sikorsky helicopter.

The contravene is a stationary component mounted directly on the engine. It is used to direct cooling air from the fan blades uniformly over the engine. Specifications called for the part to be interchangeable, lighter than the previously used metal part, and strong.

Glass cloth-epoxy was selected be-

DON'T MISS AN ISSUE — Changing your address? If so, please let us know two months in advance. With such notice, which we need for efficient operation, we will do our best to see that you don't miss an issue. Be sure to include your new postal zone number.

Falcon missiles travel "first class" in containers secured by LINK-LOCK

Fourteen No. 2 LINK-LOCK fasteners → maintain a pressure-tight seal around cover of Falcon cases.

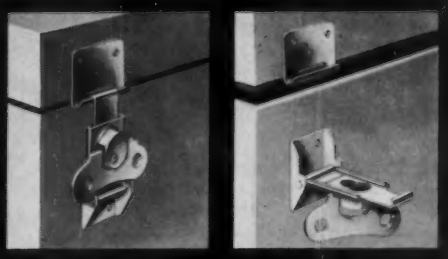
Before they take to the skies, Falcon air-to-air guided missiles are shipped or stored in containers sealed pressure-tight by Simmons LINK-LOCK fasteners.

These precisely engineered fabricated aluminum cases are produced to Hughes Aircraft Company specifications by the following companies: Vendorlator Manufacturing Co., Fresno, California; Allison Steel Manufacturing Co., Phoenix, Arizona; Avco Corporation, Crosley Division, Richmond, Indiana.

Features like these make the LINK-LOCK ideal for use on military cases made to rigid specifications as well as on inexpensive commercial containers:

- Impact and drop resistant.
- Positive-locking without springs.
- High preloading and high load carrying capacity.
- Compact design—lies flat open or secured.
- 3 sizes, for heavy, medium, light duty.
- Flexible engagement latch design... can be varied to suit different applications.

Write for Catalog #1257. Contains complete details of LINK-LOCK and other Simmons Fasteners with unlimited money-saving applications. Samples and engineering service available on request.

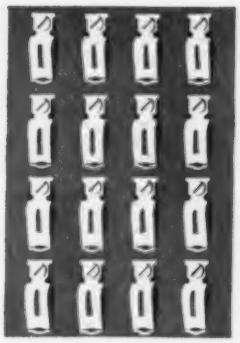


Half-turn applies high closing pressure, counter-turn disengages for opening. LINK-LOCK lies flat open or closed.

SIMMONS
FASTENER CORPORATION
North Broadway, Albany 1, New York
QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK
DUAL-LOCK • HINGE-LOCK
See our 8-page catalog in Sweet's Product Design File

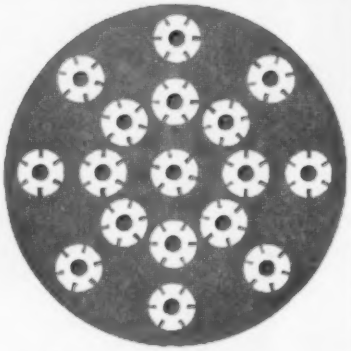
For more information, turn to Reader Service card, circle No. 423

Better strip products



from the start with

continuous-cast



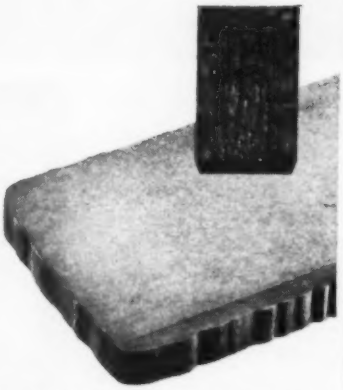
Flexograin phosphor bronze

Uniform, fine-grain Riverside phosphor bronze—Flexograin—is made even better through Riverside's *exclusive* continuous-casting process.

Riverside continuous casting eliminates porosity and assures a dense, homogeneous material that responds more readily to forming and develops uniformly high fatigue properties not attainable with ordinary phosphor bronze.

And Flexograin, being of a naturally finer grain structure, maintains the ductility and smoothness of finish that are unattainable with ordinary phosphor bronze strip.

Send for free Technical Bulletin describing Flexograin and its advantages in your production.
Write to *Riverside-Alloy Metal Division, H.K. Porter Company, Inc., Riverside, N.J.*



Good riddance to "Swiss Cheese" castings! Riverside continuous-cast, dense bronze offers time savings through faster fabrication in addition to improved product quality!

RIVERSIDE-ALLOY PORTER METAL DIVISION

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Copper and Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

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Union Carbide Plastics Co., Div. of Union Carbide Corp.

Reinforced epoxy *contravene in perfect condition after 15 million cycles on a test engine.*

cause it satisfied all of these requirements and because it provides excellent interlaminate strength, thus minimizing the effects of constant vibration.

Beryllium to Shield First Man in Orbit

When the first man is rocketed into orbit around the earth sometime within the next few years, his chances of surviving the enormous frictional heat created during reentry will be quite good—thanks to a 6-ft dia heat shield made of beryllium.

The large shield, produced by Brush Beryllium Corp., will be positioned behind the "cockpit" to absorb heat when the capsule strikes the earth's atmosphere after orbiting at about 100 miles altitude (see accompanying photo). Beryllium was selected because of its "unusual ability to absorb large quantities of heat, and its equally unusual ability to conduct heat," and thus prevent disastrous surface heat concentration. In addition, beryllium is lightweight, as strong as mild steel, and about 50% more rigid than the stiffest steel.

The shield will be fabricated from a huge billet made by powder metallurgy. Because the largest powder metallurgy press in existence can only produce a beryllium billet 64 in. in dia, the billet will have to be forged to increase its overall size to

Hands of the Giants

crack an egg or shape a missile

100,000,000 lbs. of pressure—so delicately controlled that it can be made to crack the shell of an egg. Use the fabulous forces of present day forging skills to crack the barriers of space—weight, strength, high temperatures. Forge the future, today.

EST. 1883

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ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
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Chicago 38, Illinois

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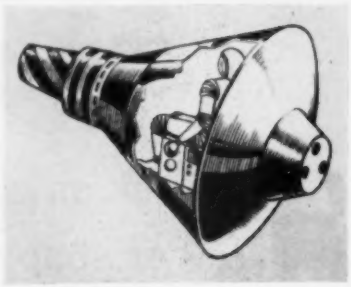
MATERIALS AT WORK



***Artist's conception** of space capsule and beryllium heat shield.*

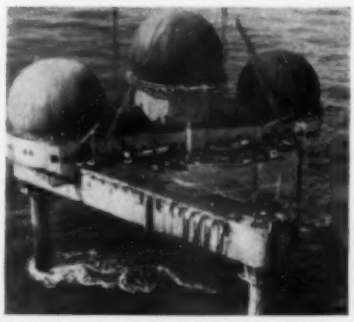
72 in. in dia. Thickness of the section will be 3 in. After forging, the shield will be machined to final dimensions.

PVC Piping Replaces Copper-Nickel Alloy

Damaging electrolytic action has been eliminated by the switch from a copper-nickel alloy to rigid polyvinyl chloride for piping and fittings used in the cooling system of the offshore radar station shown in the accompanying photo.

The cooling system, used for the power generators, utilizes salt water. After 18 months, electrolytic action (caused by the immersion in salt water of the copper-nickel piping and a stainless steel coolant jacket) had damaged the piping so severely that one set of generators had to be shut down for repairs.

Polyvinyl chloride tubing not only has solved the corrosion problem, but costs only about one-half of the previously used copper-nickel alloy.



***Offshore radar station** uses PVC piping to avoid electrolytic corrosion.*

STAINLESS STEEL SAYS "NO" TO DENTS!

It is not indestructible, of course, but it comes closer to this ideal characteristic than any other metal commercially available. What's more, it resists heat, rust and corrosion, and will not peel. These advantages may seem too obvious to mention—yet they are the very reasons why so many people who design, create, or buy things to endure insist on stainless steel. Nothing lasts so beautifully! And remember: The very *best* stainless steels are made with Vancoram Ferro Alloys.

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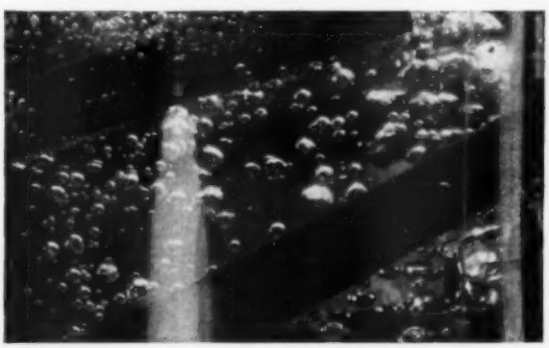
New FLUOREL Brand Elastomer is a highly fluorinated synthetic rubber that successfully resists corrosive chemicals, fuels, solvents, and ozone

FLUOREL Elastomer is rated for continuous long-time service at 400° F . . . tolerates 600° F temperatures, and higher, for reduced periods under some service conditions. Ease of processing, non-combustibility, and excellent resistance to compression set are other outstanding features.

FLUOREL Elastomer greatly extends the performance range of applications requiring elastomeric materials. Its many exciting possibilities make it an important member of the ever-expanding family of 3M organic fluorine compounds. For complete data, write: 3M, Chemical Division, Dept. KAR-89, St. Paul 6, Minn.

*The term "FLUOREL" is a trademark of Minnesota Mining and Manufacturing Company.

EASE OF PROCESSING is shown by this disc. Note the reproduction of machine marks from mold surface. FLUOREL Elastomer can be readily mold processed on standard rubber compounding and fabricating equipment. It may be molded, extruded and bonded to most metals.



WHEREVER THE HEAT'S ON, put FLUOREL Elastomer to work for you. It's in use now or under evaluation in the missiles and aircraft, automotive and chemical processing industries for oil seals, "O" rings and gaskets. Other suggested uses: fire walls, air ducts, fuel cells, fuel and hydraulic hose, diaphragms and tank linings

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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More and Better Materials Education Needed

More engineering students in more colleges must be educated in the fundamentals and properties of materials in order to solve the materials problems that are now limiting our technical progress.

This was the recurring comment heard during the Symposium on Education in Materials held in June during the annual ASTM meeting in Atlantic City. The symposium was sponsored jointly by the American Society for Testing Materials and the American Society for Engineering Education.

Lack of uniformity

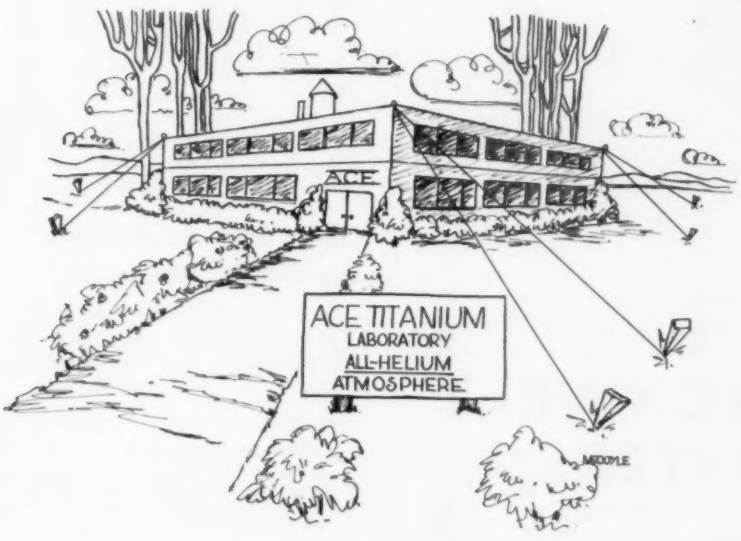
K. B. Woods, president of ASTM, in his introductory remarks, observed that there is little uniformity of content in the undergraduate materials courses given at the 25 colleges he visited recently. And he questioned whether presently available courses give engineering students what they need to know to efficiently select and use materials when they get out into industry.

Incoming ASTM president F. L. LaQue, and other speakers, said that increased attention in materials education must be given to relating properties and behavior to the fundamental structure of the materials. Improved materials education is important, he said, because "the rate of progress in such fields as the utilization of nuclear energy, the penetration of outer space, and the more economical generation of power from conventional fuels is dependent upon the solution of materials problems."

Recommendations

A report on the evaluation of education in materials and recommendations for teaching the science of materials was presented by Glenn Murphy, vice president of ASEE. He said that in many current courses the study of materials is largely descriptive and has little permanent value. The objective of the new teaching program proposed by ASEE is to develop an understanding of the inter-relationship among properties, environment, and structure. Such training, he said, would provide students with a firm foundation that would serve them throughout their entire career. M. E. Shank, professor at Massachusetts Institute of Technology, described materials courses instituted recently at MIT which follow the general recommendations made by ASEE. For example, the undergraduate materials courses for mechanical engineers cover mechanical behavior (plasticity and fracture) from an atomistic viewpoint. The school also has established a two-year graduate course in materials engineering.

The symposium seemed to indicate that much-needed attention is at last being given to education in materials. Such attention, it is believed, will result in changes and advances in college curricula that will better prepare the engineer to understand and use modern materials.



Improved Steels Aim of New Lab

"Steel industry research to date has only scratched the surface," according to T. F. Patton, president of Republic Steep Corp. " . . . From ore to finished product, steel technology is undergoing a revolution . . . and . . . we are determined to do our share of the work that will

For almost every hardness testing requirement

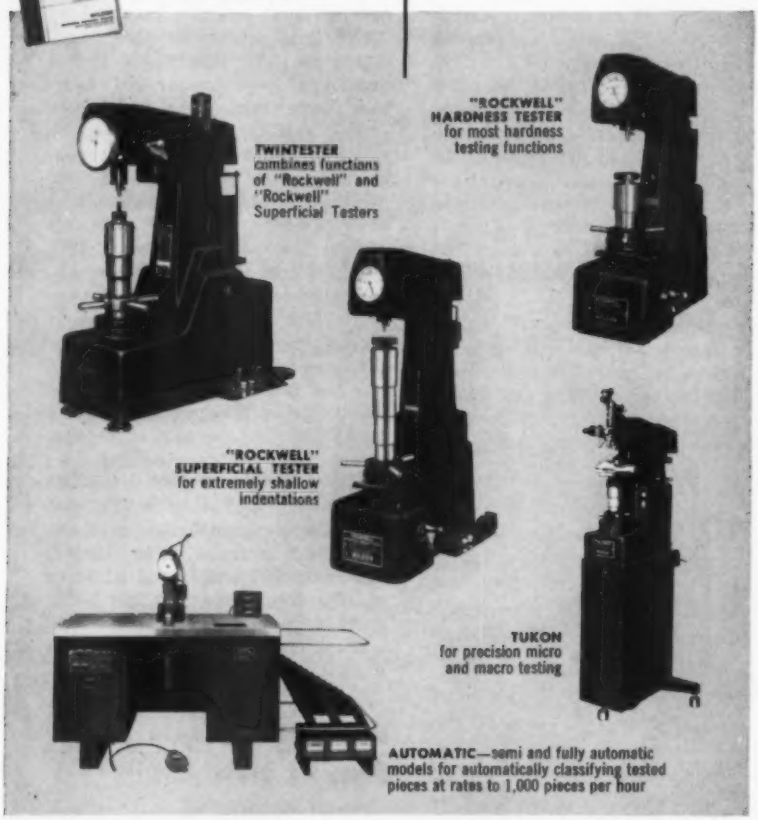
There's a Wilson "Rockwell" instrument to do the job

Wilson "Rockwell" Hardness Testers can help make your products better, stronger, longer lasting. They give reliable results on the production line, in laboratories, in tool rooms, and in inspection departments. They're as easy to use as a center punch, as durable as a machine tool, as sensitive and accurate as a precision balance. That's why Wilson "Rockwell" is recognized as the world's standard of hardness testing accuracy.

Wilson "Brale" Diamond Penetrators give Perfect Readings

A perfect diamond penetrator is essential to accurate testing. Only flawless diamonds are used with Wilson "Brale" penetrators. Each diamond is cut to an exact shape. Microscopic inspection and a comparator check of each diamond—one by one—assure you of accurate hardness testing every time.

Write for Catalog RT-58. It gives complete details on the full line of Wilson hardness testing equipment.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combines functions of "Rockwell" and "Rockwell" Superficial Testers
"ROCKWELL" HARDNESS TESTER
for most hardness testing functions
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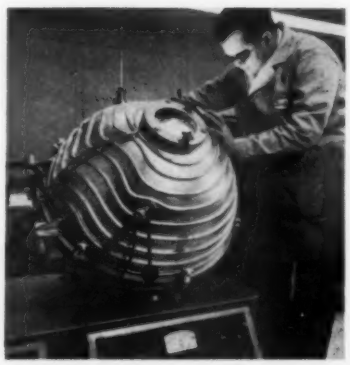
News OF INDUSTRY



Vacuum melting furnace *in Republic's new laboratory will be used to develop new steels.*

go into that revolution, and to share in the benefits that will come from it."

These remarks, made at the dedication of a new $5-million Research Center, indicated the direction in which Republic's research will be aimed. Work in the new laboratory is divided into four areas: metallurgical, processing, new products and ceramics. According to Mr. Patton, the budget will be divided as follows: 30% will be applied to research projects designed to show results in one to three years; 30% to exploratory projects keyed to a five year schedule; 30% to long-range studies that may run ten years or more; and 10% to pure science and fundamental research.

The laboratory includes an extensive pilot plant area. The first pilot plant to be set up may be Republic's new process for rolling strip steel from powder (see p 136).

Technical Conference on Semiconductors

A technical conference on properties of elemental and compound semiconductors has been scheduled

PROPERTIES of most engineering materials can be found in the second edition of M/DE's *Materials Selector* reference issue, published last October. Names and addresses of suppliers are also listed.

Beat the Heat Barrier With Handy & Harman High Temperature Brazing Alloys!

Some of the problems of elevated temperature joint strength and oxidation resistance in heat-resistant alloys are being solved today by a relatively new group of Handy & Harman high temperature brazing alloys. These alloys embody certain unique characteristics, all of which are requisite for high temperature brazing:

- They have good strength and oxidation resistance at recommended temperatures.
- They are ductile, with the ability to withstand vibration and stress at elevated temperatures.
- These Handy & Harman alloys provide minimum solution and penetration of the metals being joined; this is a particular advantage when joining thin sections.
- These alloys effectively join stainless steels, low alloy steels, nickel-base alloys, cobalt-base alloys and other high temperature metals including refractory types.

The list of successful applications includes jet engine parts, heat exchangers, rocket motors, clad metals, honeycomb structures, turbine blades and many others. The following are brief descriptions of these Handy & Harman alloys:

LITHOBRAZE 925 For short time operation to 900° F, continuous at 500° F. Very ductile, virtually no solution of base metal. Good salt-spray corrosion resistance.

HI-TEMP 30 For continuous service 900° F-1000° F. Fairly ductile, moderate general solution of base metal.

PREMABRAZE 128 Continuous service up to 1500° F. Ductile, moderate solution of the base metal. Tensile strength at 1600° F in 304 stainless steel is 20,000 psi (short time test).

PREMABRAZE 130 Same properties as PREMABRAZE 128, but freer flowing and lower brazing temperature.

PREMABRAZE 101 Continuous operation in 1800° F-2000° F range (based upon limited oxidation tests). Ductile, moderate solution and penetration of the base metal.

Alloy	Nominal Composition	mp° F	fp° F
LITHOBRAZE 925	92.5 Ag 7.3 Cu .2 Li	1435	1635
HI-TEMP 30	70 Mn 30 Ni	1885	1920
PREMABRAZE 128	72 Au 22 Ni 6 Cr	1785	1900
PREMABRAZE 130	82 Au 18 Ni	1740	1740
PREMABRAZE 101	54 Pd 36 Ni 10 Cr	2250	2300

Data sheets and complete details on each of the above Handy & Harman alloys are available upon request to Handy & Harman, 82 Fulton Street, New York 38, N. Y.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

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General Offices: 82 Fulton St., New York 38, N. Y.

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LOW COST SOLUTION TO HIGH PRODUCTION COSTS

Die cast aluminum air drill handle manufactured by Production Die Casting for the Cleco Air Tools Division of the Reed Roller Bit Company.

Lawn edger blade guard

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PRECISION DIE CASTING has helped manufacturers hold the price line in spite of steadily rising labor and commodity costs. This superior and economical method of fabricating component parts for trucks, automobiles, household appliances and many other products of wide application virtually eliminates the necessity for costly machining and finishing.

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News OF INDUSTRY

by the Metallurgical Society of AIME for Aug 31-Sept 2, at the Statler Hotel, Boston.

Some of the subjects to be covered include: the role of dislocations in device properties (panel discussion), dislocations in semiconductors, semiconductor surfaces and films, stoichiometry in compound semiconductors, properties of silicon carbide and gallium phosphide for power rectifiers, compound semiconductors for transistors and transistor-like devices, and new compound semiconductors.

Materials Research, Then Hardware Asked

If a fraction of the $900 million that has been spent so far in trying to develop a nuclear aircraft had been spent in materials research, a nuclear airplane would now be flying.

That is the opinion of T. Keith Glennan, head of the National Aeronautics and Space Administration.

"We in this country tend to go too fast into hardware," Dr. Glennan says. He spoke recently at the dedication of Republic Steel's new research laboratory in Independence, Ohio (see p 192).

Dr. Glennan also suggested that "the time has come to change our concept of the metallurgical industries." Instead of thinking in terms of the steel industry, or the aluminum industry, he said, "we should consider them all together as interlocking segments of one dynamic materials industry.

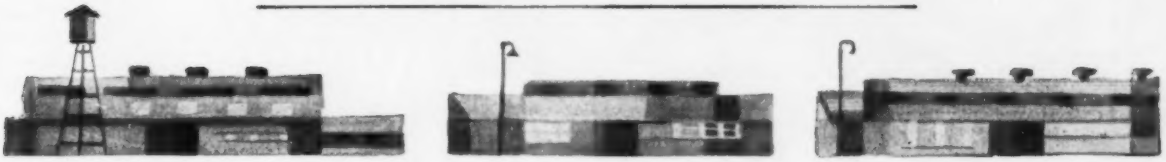
"Only thus," he said, "can the vast potential of industry in creative technology serve the varied needs of advanced design."

SPI Acts to Halt Deaths from Plastics

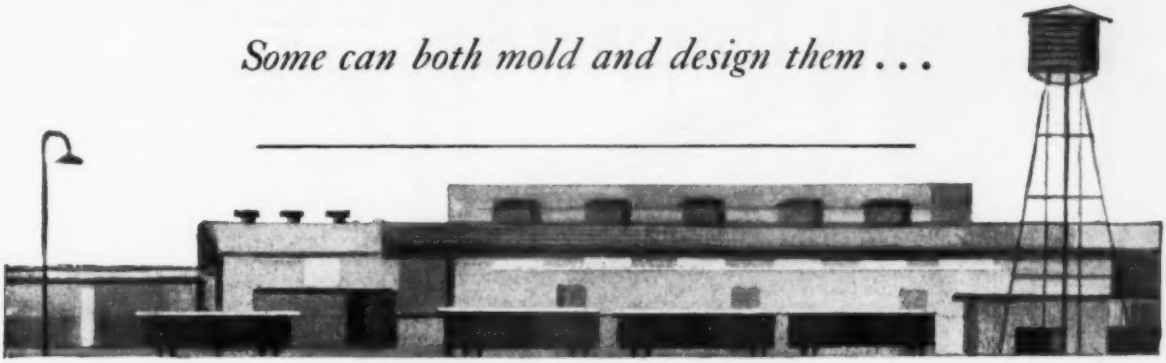
About 60 children, mostly under one year old, have suffocated and died as a result of becoming enmeshed in polyethylene bags used to protect food, clothes, etc. According to the National Safety Council, another 40 may lose their lives in the same manner before the year is over.

The increasing number and size

Hundreds of companies can mold plastics . . .



Some can both mold and design them . . .



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GENERAL AMERICAN

Plastics Division

General American's Plastics Division offers you advantages that no other molder in the world can match!

- The largest and most varied molding facilities in the industry, with compression presses up to 2000 tons for regular and reinforced plastics in simple and complex shapes, injection presses up to 300 ounces, and large extruding and vacuum-forming machines.
- An experienced staff of research and development specialists, and a complete engineering department.
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These are some of the reasons why General American is the nation's leading custom molder of plastics. Let us study your products to help you determine whether the use of custom molded plastics will improve them. You'll find . . . *it pays to plan with General American.*

Plastics Division

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135 South LaSalle Street, Chicago 90, Illinois

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Chace

THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

the CTS TUBESAVER

A PRODUCT OF
CHICAGO TELEPHONE
SUPPLY CORP., ELKHART, INDIANA

Here's an efficient little protective device for television circuits, manufactured by Chicago Telephone Supply Corporation. The Tubesaver consists principally of a thermistor in the line circuit to eliminate the current surge when the set is turned on and a thermo-delay bimetal switch in the B+ circuit which remains open until the tubes are fully warmed. The design of the bimetal element permits the set to warm up 15 to 45 seconds before the plate voltage is applied. Such protection has led some of the manufacturers to increase warranty time on all of the components, as the Tubesaver eliminates the damaging electrical surge on cold tube filaments, and prevents "cathode stripping" by allowing a slow warm-up.

The fantastic growth of the television industry, with millions of sets being produced each year, with constant improvement in design and quality, yet with generally lower and lower costs to the consumer, is a concrete tribute to the engineering, development and production genius of the manufacturers. We're proud to point out that Chace has kept pace with the best in the industry, providing the precious bits of thermostatic bimetal which actuate such devices as the Chicago Telephone "Tubesaver." Our third of a century of experience in the creation of such critical elements is one of the most important qualities you get in Chace Thermostatic Bimetal, second only to the unvarying precision of our alloys, our bimetal combinations and our fabricating of the elements, strips or coils we make to your specifications.

If you have a new temperature responsive product or one in the "thinking" stage, send for our booklet, "Successful Applications of Chace Thermostatic Bimetal." It contains many pages of useful engineering data and design information on our more than 30 different types of bimetal.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

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News OF INDUSTRY

of headlines in recent newspapers has perhaps tended to overstate the problem. However, a problem does exist and realistic action is being taken by the Society of the Plastics Industry and many official city and state groups.

According to SPI, the crux of the problem seems to lie in the *misuse* of plastics packaging film. Instead of disposing of the bags once they have served their purpose, parents have been allowing children to use them as playthings. To discourage this practice, SPI has published a pamphlet entitled "Helpful Hints To Parents on the Correst Use and Misuse of Plastics Film." Over 2 million copies of the pamphlet have been distributed through such organizations as the American Academy of Pediatrics, American Academy of General Practice, National Institute of Drycleaning, Inc., the National Safety Council, the Public Health Service, and many city and state Health Departments.

Some cities (New York, for example) have amended their sanitary codes, making it mandatory for warning labels to be placed on plastics bags. Many state legislatures have already passed or are considering bills requiring such warning labels. Other suggestions: use of thicker, nonclinging film, and use of perforated film.

Engineers

John L. Everhart, metallurgical engineer and former Technical Editor of M/DE, is now affiliated with International Nickel Co.

Albert M. Nutter, E. L. LeBaron Foundry Co., has been elected vice president of the National Castings Council.

D. V. Rosato is now assistant plant manager of Raytheon Mfg. Co.'s new Research Div. plastics plant in Maynard, Mass.

Ralph D. Wysong, Studebaker-Packard Corp., has been elected president, American Electroplaters' Society, Inc.

Harry R. Marty has been appointed manager of the new Owensboro, Ky. plant built by W. R. Grace & Co.'s Dewey & Almy Chemical Div. for the manufacture of polyvinyl acetate

This book can help solve your wire problems . . .

WIRE SHAPED TO FIT YOUR DESIGN

• The book shown above can help you improve your product and cut your costs. It explains why, if your design involves wire with special or unusual cross-section, PAGE shaped wire is the answer. Shaped wire saves material, eliminates machining, forming, forging or similar operations. When you specify PAGE shaped wire, you get these additional advantages:

The shape you need • PAGE can furnish all of the standard shapes, such as squares, ovals, flats and keystones, as well as hundreds of special shapes made to your own drawings and specifications.

Extra strength • PAGE shaped wire is stronger than hot-rolled material. The cold drawing of PAGE shaped wire increases tensile strength, yield point and hardness —improves both wear resistance and machineability.

Many grades of steel • You can specify low carbon, high carbon, alloy or stainless steels, and Armco ingot iron. We'll be glad to recommend the steel best suited to your application.

Accuracy • Both the cross-sections and contours of PAGE shaped wires are extremely accurate, the result of careful cold-drawn or cold-rolled processes in our mill.

Packaged right • PAGE shaped wire is furnished in either standard or special coils of exact weight. Straightened and cut wire is available in either exact or random lengths. It's packaged in bare bundles, wrapped in waterproof paper, burlapped, in cartons, boxes, Leverpaks, or other ways to meet your requirements.

PAGE shaped wire can save you money. The modern well screen is a good example. Once made by sawing slots in tubes (which clogged quickly), well screens are now made from screening formed from special shaped wire. The result is a screen with superior non-clogging features.

When you buy shaped wire, it pays to select a source with experience you can use. PAGE has been manufacturing shaped wire for more than 50 years—our know-how is your assurance of expert service. Why not ask us for a quotation?

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Page Steel and Wire Division • American Chain & Cable Company, Inc.

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Houston, Los Angeles, New York, Philadelphia, Portland, Ore., San Francisco, Bridgeport, Conn.

WRITE FOR BOOK . . .

• For details on PAGE shaped wire, write us at Monessen, Pa., for **DH-1226.** This helpful book contains data on carbon and alloy steel weights—explains methods of calculating areas of common shapes—lists physical properties of steel wire. Also contains hardness conversion tables and standard wire gauge tables, along with other useful information.

Typical Uses for PAGE Shaped Wire

Bag frames	Generators	Screen wire
Belt buckles	Handles	Shoe buckles
Bobby pins	Hose wire	Snap rings
Business machines	Keys	Springs
Casing wire	Lamp shades	Switches
Conduits	Lock washers	Typewriters
Cotter pins	Push-Pull controls	Welding strip
Furniture hardware	Rakes	Well screens
Furniture trim	Retainer rings	Wrenches

PAGE *-the source for answers to wire problems*

For more information, turn to Reader Service card, circle No. 472

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- **PAPER** offers a thin fibrous mat for lining oil-fired combustion chambers, a resilient pressure distribution and thermo-balance sheet for stainless steel honeycomb brazing, as well as a gasketing material.
- **BLOCK** features low thermal conductivity and heat capacity, immunity to thermal shock and inertness in hydrogen and other atmospheres.
- **FELTS** provide a convenient insulating wrap for high temperature pipes, flanges and furnace parts.
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News OF INDUSTRY

polymers and copolymers, butadiene styrene synthetic rubber latices, and battery separators.

James M. Planten has been named vice president, Foundry Design Co.

Robert E. Hebert has been appointed manager of Vanadium-Alloys Steel Co.'s new Vacuum Melting Dept.

Robert L. Jackson has been named production manager, Scientific and Process Instruments Div., Beckman Instruments, Inc.

Dr. John Frederick Dunn, Jr., has been appointed chief engineer, Walworth Co.

Edmund G. Shower is now production engineering manager, Sperry Semiconductor Div., Sperry Rand Corp.

Richard A. Kirk has been appointed chief project engineer, Tamar Electronics, Inc.

William A. Roach, Jr., has been appointed product manager, J. E. Lonergan Co.

Gilbert Tint has been named vice president and chief engineer, National Ultrasonic Corp.

Leland E. Bruce has been named assistant production manager, Chemical Milling Div., U. S. Chemical Milling Corp.

George Konkol has been named to the newly-created position of general manufacturing manager, Parts Div., Sylvania Electric Products Inc.

Charles E. Maki has been appointed chief development engineer, MB Mfg. Co., a division of Textron, Inc.

Jan Mueller has been appointed manager, jet engine component manufacturing, American Metal Products Co.

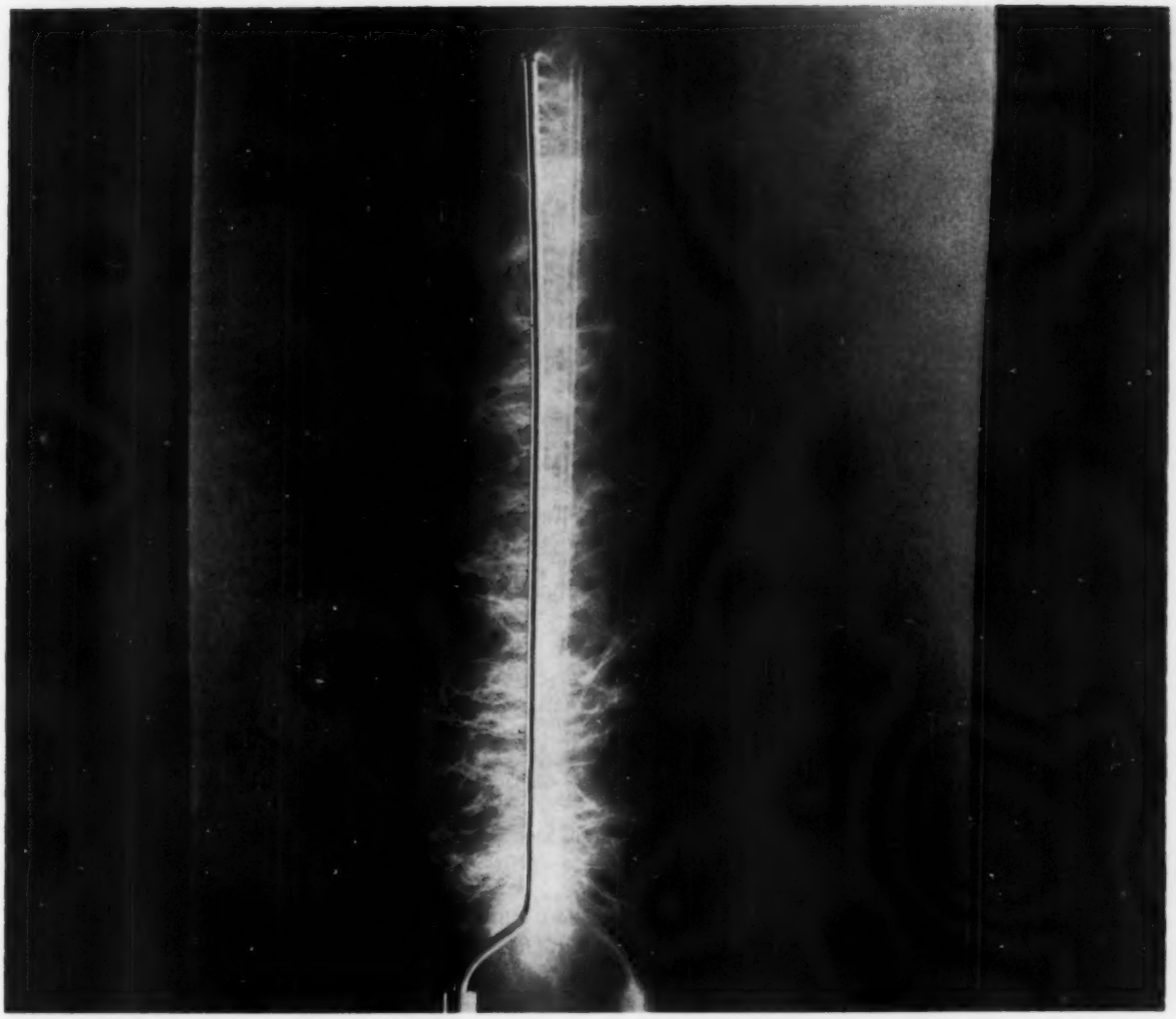
Leo DeFiore has been appointed director of engineering, and **Carl J. Lucas** has been named chief engineer, Youngstown Sheet & Tube Co.

Dr. Val Kudryk has been named director of research and development, Accurate Specialties Co., Inc.

Donald W. Kase has been named production engineer assisting the director of operations, Michigan Chemical Corp.

Ross Holmes has been named manager, Pre-Mix Dept., Hoeganaes Sponge Iron Corp.

Dr. Siegfried Lindena has been appointed director of advanced research,



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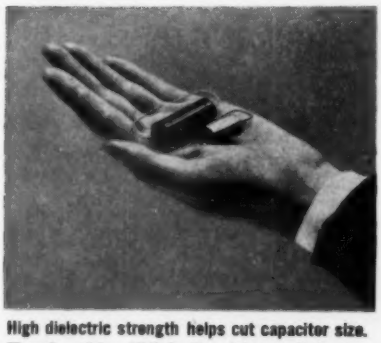

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On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't embrittle with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar" can help you solve knotty design problems, improve product performance or cut costs. Write for our booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Rm. MM-8, Wilmington 98, Del.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

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STRAITS TIN REPORT

News of developments in the production and uses of tin

MALAYAN TIN BUREAU

Zircalloy 2 – containing 1.5% or more tin – was the cladding material used for the nuclear power unit which carried the submarine Nautilus across the North Pole. Zirconium alone couldn't do it. Addition of small quantities of tin strengthened the zirconium and reduced the variable effect of impurities. It also had a favorable effect on its corrosion resistance. This discovery led to development of Zircalloys containing 0.5 to 5% tin.

Factory fresh hosiery is now available to American consumers in tin cans. The manufacturers claim canning nylons reduces pilferage and handling costs, lets the lady select her nylons factory fresh from her grocer's shelf.

Foreign car manufacturers are capitalizing on latest developments in tin applications. Directional signals, subject to continuous wear and hard weather conditions, are electroplated with a tin-zinc coating. A tin-nickel electrodeposit shows good potential as a bright tarnish-resistant coating for automotive trim, bumpers and accessories. A tin-bronze coating of up to 12% tin and a tin-nickel coating of two-thirds tin are proving excellent undercoatings for chromium.

Write today for more data on these items or for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau
Dept. 24H, 1028 Connecticut Ave., Washington 6, D.C.

For more information, circle No. 379

News of Industry

Special Products Div., Networks Electronic Corp.

Robert E. Root has been appointed manager, Electro-Mechanical Div., American Electronics, Inc.

Charles Peterson is now chief engineer, Veet Industries, Detroit.

L. S. Hilton has been named manager, Abrasive and Diamond Wheel Depts., Manhattan Rubber Div., Raybestos-Manhattan, Inc.

Edgar E. Wrege has been made operations manager, Special Products Dept., Avisco Film Div., American Viscose Corp.

Companies

Universal-Cyclops Steel Corp. has begun production in its new multi-million-dollar stainless steel strip plant at Coshocton, Ohio.

Hooker Chemical Corp. has completed its new multi-million-dollar research center at Grand Island, N. Y.

Aerospace Industries Assn. of America Inc. is the new name of **Aircraft Industries Assn. of America Inc.**

Bettinger Corp. has moved to new quarters at 55 W. 42nd St., New York City.

Snyder Corp. has purchased **Hope Machine Co.**

EverLube Corp. has formed a new plating division located at 6940 Farmdale Ave., North Hollywood, Calif.

Technical Operations, Inc., has begun an expansion of its Burlington, Mass., research facilities.

Caloric Appliance Corp. will construct a research and development center at its Topton, Pa., plant.

Leece-Neville Co. of Cleveland has purchased **A. C. Motor Div.,** O. A. Sutton Co., Wichita, Kan.

Diamond Alkali Co. plans to build a multi-million-dollar research center near Painesville, Ohio.

Robertshaw-Fulton Controls Co. has begun construction of a $4-million plant at New Stanton, Pa.

Hamilton Standard Div., United Aircraft Corp., has formed a new department for the design, develop-

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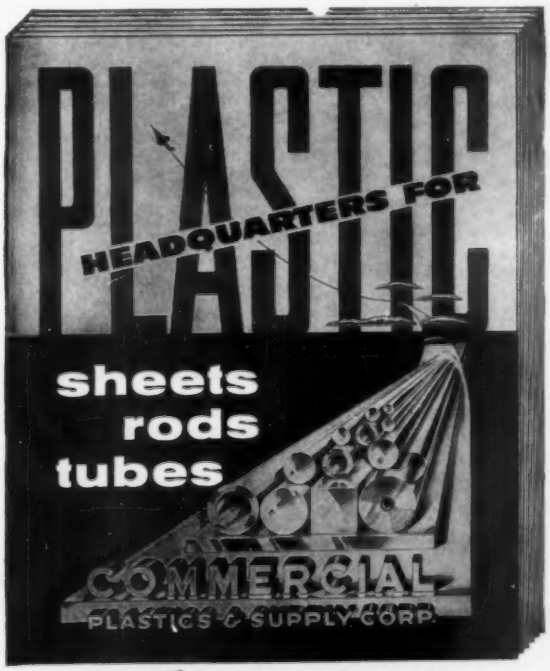

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News OF INDUSTRY

ment and manufacture of specialized ground support equipment for missiles and aircraft.

Hostachem Corp. is the new name for **Progressive Color and Chemical Co., Inc.,** 350 Fifth Ave., New York City.

NRC Equipment Corp. has established a West Coast engineering office at Palo Alto, Calif.

A. O. Smith Corp. has begun construction of a new $2.1-million addition to its Kankakee, Ill. plant.

Owatonna Tool Co. has formed a new Precision Hydraulics Div.

Ramo-Wooldridge Div., Thompson Ramo Wooldridge Inc., has reorganized its Los Angeles engineering group to form a new Systems Technology Div. and a Data Processing Div.

International Rectifier Corp. is constructing an 80,000-sq ft plant at 222 Kansas St., El Segundo, Calif.

Baird-Atomic, Inc. has acquired four companies as part of a major expansion program. They are: Atomic Assoc., Inc., of New York; Atomic Assoc., Inc., of California; Atomic Accessories, Inc.; and Atomic Development & Machine Corp.

Cutter Laboratories has acquired the assets of **Olympic Plastics Co., Inc.,** Los Angeles.

Universal-Cyclops Steel Corp. has purchased the Bridgeville, Pa., property of **Flannery Mfg. Co.**

Keokuk Electro-Metals Co. and **Vanadium Corp. of America** have announced a merger whereby Keokuk will operate as a division of Vanadium Corp.

Moldings & Extrusions Inc. is a new corporation specializing in precision molding and extrusion of industrial plastics. Headquarters are located in Wauregan, Conn.

Carlon Products Corp. has purchased a new 100,000-sq ft plastics pipe plant in High Springs, Fla.

Cycleweld Chemical Products Div. is the new name for **Cycleweld Cement Products Div.,** Chrysler Corp.

SKF Industries, Inc., has begun a $4½-million expansion program at its Altoona, Pa. plant.

Chemstrand Corp. plans to construct a Nylon Development Center near Pensacola, Fla.

Monsanto Chemical Co.'s Inorganic Chemicals Div. has begun a moderni-

A convenient new guide to properties and uses . . .

ASBESTOS:

It's Industrial Applications

by D. V. ROSATO

Assistant Plant Manager
Research Division, Plastics Plant
Raytheon Manufacturing Co.

1959, 224 pages, $5.75

The author compiles and presents all available data on the properties and applications of asbestos, including recent advances. The book identifies the broad usage of asbestos in many engineered products. It serves as a convenient guide to various branches of industry including research and development groups, manufacturers, engineering schools, market research groups, and sales management. In addition to acquainting industry with asbestos products in a great variety of fields, the book also reviews the types of asbestos material available, their properties, and methods of manufacturing to further the understanding of the variables which exist in handling asbestos.

CONTENTS: Industrial Applications of Asbestos; Properties of Asbestos; Asbestos-Cement; Tile; Asbestos Heat Insulation; Asbestos Electrical Insulation; Asbestos Friction Materials; Asbestos Textiles; Plastics; Asbestos Packings and Gaskets; Asbestos Filters; Other Products; Census on Asbestos Products; Bibliography; Index.

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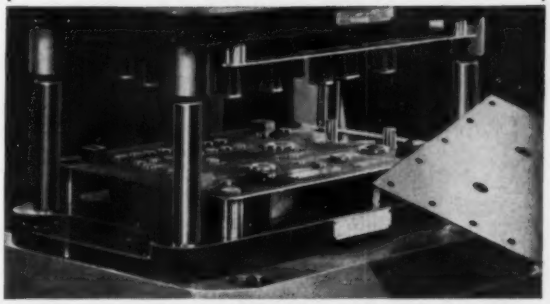

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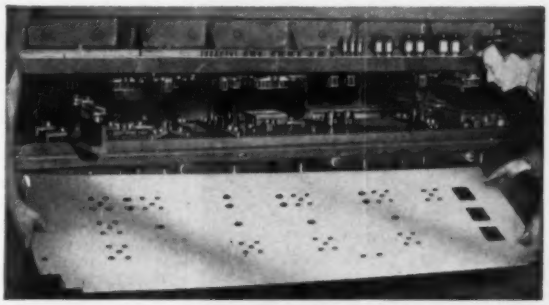

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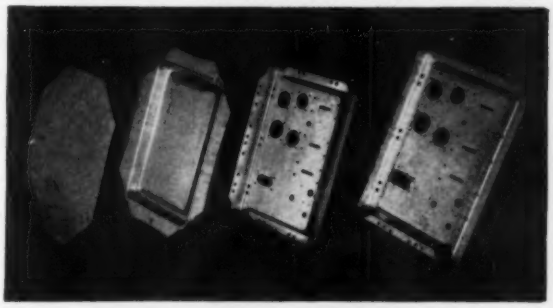

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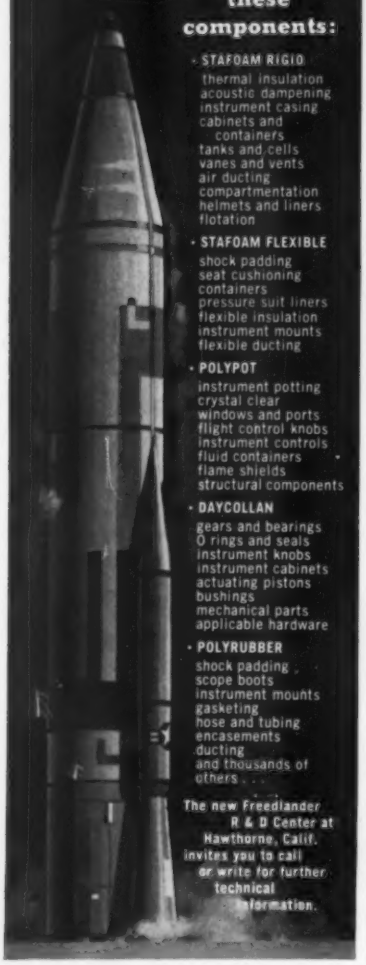

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News OF INDUSTRY

zation program of its elemental phosphorus plant at Columbia, Tenn.

Acoustica Asso., Inc. has acquired **Universal Dynamics Corp.**, which will operate as a wholly-owned subsidiary of Acoustica.

Societies

Copper & Brass Research Assn. has elected the following officers: president—James M. Kennedy, Revere Copper and Brass Inc.; senior vice president—D. W. Blend, Wolverine Tube Div., Calumet & Hecla, Inc.; vice presidents—G. P. Bakken, Chase Brass & Copper Co., Inc.; C. P. Goss, Scovill Mfg. Co.; Justice Lockwood, American Brass Co.; Allen R. Roach, Penn Brass & Copper Co.; F. R. Slagle, Miller Co.; F. W. Sullivan, United Wire and Supply Corp.; J. E. Williams, Olin Mathieson Chemical Corp.; and Austin R. Zender, Bridgeport Brass Co.; treasurer—F. L. Riggin, Sr., Mueller Brass Co.; managing director—T. E. Veltfort; and secretary—Carl H. Pihl.

Vinyl-Metal Laminators Institute is a new division of the Society of the Plastics Industry, Inc.

American Welding Society announces the following 1959-60 officers: president—Charles I. MacGuffie, Air Reduction Sales Co.; first vice president—R. D. Thomas, Jr., Arcos Corp.; and vice president—A. F. Chouinard, National Cylinder Gas Co. Directors are: Frank Singleton, Singleton Welding Supply Co.; Jay Bland, General Electric Co.; Charles B. Smith, Douglas Aircraft Co.; J. R. Stitt, R. C. Mahon Co.; George W. Kirkley, General Dynamics Corp.; Joseph W. Kehoe, Westinghouse Electric Co.; Harold E. Schultz, General Electric Co.; Lester L. Baugh, Allis Chalmers Mfg. Co.; Clifford L. Moss, Wyatt Metal and Boiler Works; and C. B. Robinson, Air Reduction Pacific Co.

Society of the Plastics Industry, Inc., has elected the following officers: president and director—Russell C. Weigel, E. I. du Pont de Nemours & Co., Inc.; director and chairman of the board—C. Russell Mahaney, St. Regis Paper Co.; vice president and director—Robert L. Davidson, Kurz-Kasch, Inc.; and secretary-treasurer and director—E. J. Caughlin, American Insulator Corp.

(News of Meetings on p 206)

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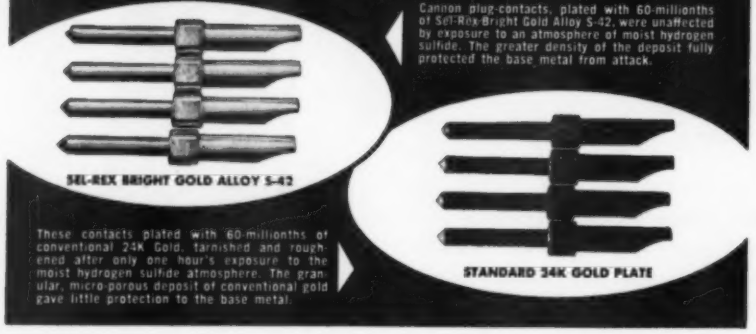
Cannon plug-contacts, plated with 60-millionths of Sel-Rex Bright Gold Alloy S-42, were unaffected by exposure to an atmosphere of moist hydrogen sulfide. The greater density of the deposit fully protected the base metal from attack.
SEL-REX BRIGHT GOLD ALLOY S-42
These contacts plated with 60-millionths of conventional 24K Gold, tarnished and roughened after only one hour's exposure to the moist hydrogen sulfide atmosphere. The granular, micro-porous deposit of conventional gold gave little protection to the base metal.
STANDARD 24K GOLD PLATE

Contacts used in world-famous Cannon Plugs must be capable of withstanding corrosion and tarnish, in addition to the punishing effects of repeated engagement and disengagement. The photographs, taken by Cannon in their own laboratory, show why conventional 24K gold plate failed to meet the requirements of this application.

Both samples were plated with 60-millionths of gold over silver plate, and were photographed after an hour's exposure to an atmosphere of moist hydrogen sulfide. The contacts plated with 24K gold tarnished and roughened—those plated with Sel-Rex Bright Gold Alloy S-42 retained their original mirror-bright finish.

Says Cannon, "At Cannon Electric, Sel-Rex Bright Gold Alloy S-42 has been instrumental in solving wear and tarnish problems encountered in connectors used in aircraft, and intricate missile and electronic components."

The foregoing is just another of our many case histories which prove that: "From Missiles and Rockets to Misses and Lockets—there's a Sel-Rex Precious Metal Plating Process to help you make your product better, more salable."

For other case histories, technical information and application data, ask for ML-1.

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News OF INDUSTR

Meetings

DENVER RESEARCH INSTITUTE, Metallurgy Div., 8th annual conference on applications of x-ray analysis. Estes Park, Colo. Aug 12-14.

INSTITUTE OF RADIO ENGINEERS AND WESTERN ELECTRONICS MFRS. ASSN., 1959 Western electronic show and convention. San Francisco. Aug 18-21.

AMERICAN SOCIETY FOR METALS, conference on fracture of engineering materials. Troy, N. Y. Aug 23-25.

METALLURGICAL SOCIETY, American Institute of Mining, Metallurgical, and Petroleum Engineers, conference on properties of elemental and compound semiconductors. Boston. Aug 31-Sept 2.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Midwest Section conference. French Lick, Ind. Sept 10-11.

AMERICAN CHEMICAL SOCIETY, 136th national meeting. Atlantic City, N. J. Sept 13-18.

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th fall meeting. Hot Springs, Va. Sept 21-22.

STANDARDS ENGINEERS SOCIETY, 8th annual meeting. Boston. Sept 21-22.

INSTRUMENT SOCIETY OF AMERICA, 14th conference and exhibit. Chicago. Sept 21-25.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept. 24-26.

AMERICAN WELDING SOCIETY, fall meeting. Detroit. Sept 28-Oct 1.

ASSN. OF IRON AND STEEL ENGINEERS, annual convention. Chicago. Sept 28-Oct. 1.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 15th New England Section conference. Portsmouth, N. H. Oct 1-2.

AMERICAN VACUUM SOCIETY, 6th national symposium on vacuum technology. Philadelphia. Oct 7-9.

GRAY IRON FOUNDERS' SOCIETY, INC., 31st annual meeting. San Francisco. Oct 7-9.

AMERICAN SOCIETY FOR TESTING MATERIALS, 3rd Pacific Area national meeting. San Francisco. Oct 11-16.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct-11-16.

FEDERATION OF PAINT AND VARNISH PRODUCTION CLUBS, 37th annual meeting. Atlantic City, N. J. Oct 20-24.

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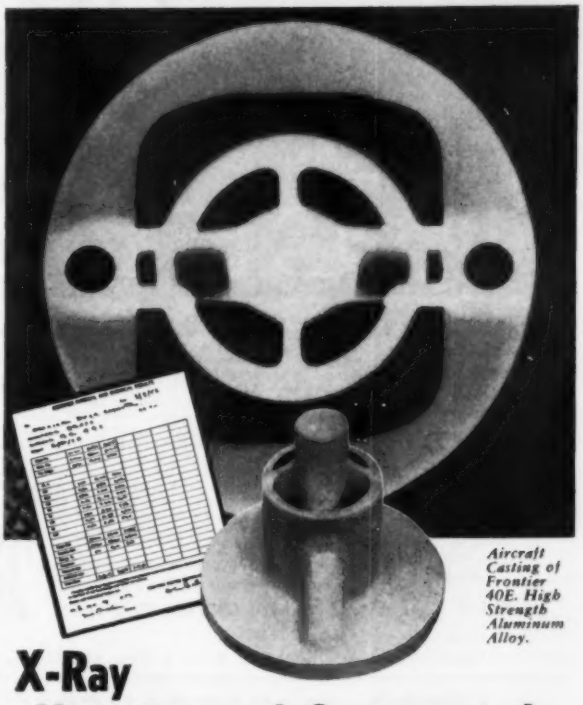

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technical components

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TECHNICAL LITERATURE

(cont'd from p 42)

Books

The Nimonic Alloys. *W. Betteridge. St. Martin's Press Inc., New York. 1959. Cloth, 6 by 9 in. 344 pp. Price $15*

This book presents comprehensive and up-to-date engineering data on a group of precipitation hardenable nickel-chromium alloys called Nimonic. The 15 chapters in this British book give information on: chemical composition, constitution, hot and cold working, heat treatment, physical properties, mechanical properties at room and elevated temperatures, corrosion resistance, joining, machining and finishing, applications, and Nimonic alloys as castings. The book is well illustrated with tables, diagrams and photographs.

Package Design Engineering. *Kenneth Brown. John Wiley & Sons, Inc., New York. 1959. Cloth, 6 by 9 in., 278 pp. Price $8.50*

Covers the fundamentals in static and dynamic mechanisms, strength of materials, and stress analysis for solving structural and dynamic packaging problems. Gives design characteristics of the tension spring, rubber shear mount, solid cushioning and canvas strap suspension systems.

Chemistry Made Easy. *Cornelia T. Snell and Foster Dee Snell. Chemical Publishing Co., Inc., New York. 1959. Cloth, 5 by 8 in., 270 pp. Price $10*

Covers the theory of inorganic chemistry, elements and compounds in inorganic chemistry, and aliphatic and aromatic compounds of organic chemistry. The book is designed specifically for home study. Its presentation makes it easy for the reader to grasp the essential principles of chemistry without a teacher.

Physical Laws and Effects. *C. Frank Hix, Jr. and Robert P. Alley. John Wiley & Sons, Inc., New York. 1958. Cloth, 6 by 9 in., 291 pp. Price $7.95*

Contains many common and uncommon physical laws and effects that may be of interest to the engineer. Gives a clear description of the law or effect, an indication of the expected magnitude, and references that will be useful in gaining additional information. The entire collection is indexed alphabetically by names, by physical quantities involved, and by fields of science.

Reports

High temperature seals A RESEARCH PROGRAM ON THE INVESTIGATION OF SEAL MATERIALS FOR HIGH TEMPERATURE APPLICATIONS. *R. H. Baskey. Horizons Inc. June '58. 74 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2 (PB 151451)*

Study of pure refractory hard metals, binary alloys of these metals bonded with nickel, and ternary alloys of these metals bonded with nickel and infiltrated with silver as rotating seal materials for potential aircraft use at high speeds and high temperatures. Two ternary alloys prepared

the LEAD newsletter

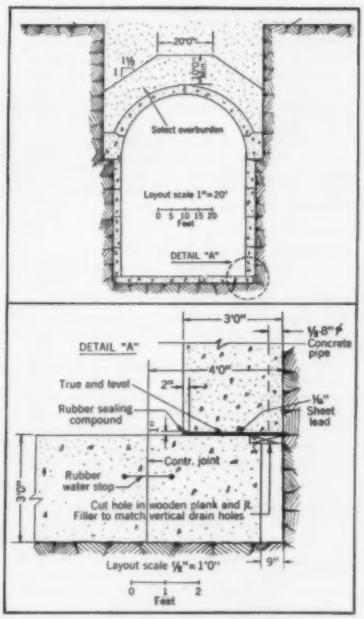
Lead is a remarkably versatile material. It is found in hundreds of familiar uses and in a wide range of entirely new applications. Here are a few of the unique properties that caused lead to be selected for use in some unusual and interesting new applications.

Practically Indestructible Electrochemically

A "lead dry cell" battery having a completely reversible electrochemical system which does not gas on charging and is therefore practically indestructible has been developed to power transistor circuits. Even after years of use its capacity, 9/10 of a volt at 1½ amperes, is not greatly affected by repeated recharging. It has high shock and vibration resistance, particularly in the temperature range of −65 to plus 165 deg. F. When mass produced, it is believed that costs would be about 50 per cent higher than a Mercury battery which does not equal its amperage-voltage-temperature advantages. The battery anode of the lead dry cell "mighty midget" battery is made of consolidated Grenox or lead-lead oxide. It weighs only 40 grams as compared with 95 grams for the conventional flashlight battery. Gram for gram, both are equal in capacity. In the uncharged state, it has a virtually indefinite shelf life.

Sound Attenuation

Materials impregnated with lead powder have proved most effective in reducing aircraft noise. The sound deadening material is a plastic such as vinyl, heavily impregnated with lead powder, and backed with glass fibre or cotton duck. Although the fabric is relatively thin, the lead mass is very effective in deadening sound. Lead in other shapes, such as sheet or foil will also act as an excellent sound isolator. As pointed out in the article "Acoustics for Modern Interiors," ARCHITECTURAL FORUM, April, 1959, "... if the wall is heavy and limp, like a soft lead sheet, it is less capable of moving with the sound waves, and sound is less likely to go through it."



Lubricity

The new Niagara Power Project will require approximately one million pounds of 1/16 inch thick sheet lead. Here lead is used as a lubricating base and seal beneath the concrete walls of 4½ miles of water-conveying conduits that pass through limestone cuts. Lead was specified because, under the influence of rock squeeze, lead's lubricity permits lateral movement of conduit walls. This maintains the conduits structurally, and lead's high sealing quality will keep water leakage at a minimum.

Optical Reflectivity

Compounds of basic lead carbonate and lead monohydrogen phosphate — through an optical effect dependent upon multiple reflectivity — are now providing a new way to duplicate the appearance of pearls or mother-of-pearl. Synthetic "pearly" pigments are being widely used in costume jewelry ... motion picture screens ... synthetic leather ... molded plastics ... and are giving a pearlized look to paint jobs on certain custom-model automobiles.

Improved Strength & Rigidity

Hard lead — an alloy containing from 6 to 7½% antimony — preserves all the desirable easy-to-work properties of soft lead, yet improves strength, rigidity and hardness. Over 8,000 lbs. of hard lead sheet line the gutters of the new dormitory building at Duke University, Durham, N. C. Hard lead was selected for this job because it resists corrosion ... will not stain the adjacent limestone ... and assures a watertight drainage system that can be counted on to last the life of the building itself.

The broad range of lead's potential uses is taking researchers into an astonishing number of widely different fields. Its unique properties continue to increase lead's value to modern technology.

Research is currently being conducted in the following important areas: low melting frits for porcelain enameling of aluminum and steel; lead ferro-electric materials; lead glazes for structural clay products; wrought lead products by powder metallurgy and many others.

If you are faced with a product development problem, lead may prove to be the ideal solution. Don't hesitate to ask for information and technical assistance. Write: Office of Technical Information, Lead Industries Association, 60 East 42nd Street, New York 17, N.Y.

1970

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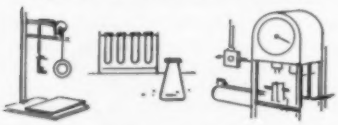

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TECHNICAL LITERATURE

by powder metallurgy techniques showed superior wear qualities when run against tool steel and Inconel. The best alloys, according to the report, contained tungsten boride or chromium nitride as the basic metal.

Design criteria for titanium DETERMINATION OF MATERIALS DESIGN CRITERIA FOR 6 Al-4 V TITANIUM ALLOY AT ROOM AND ELEVATED TEMPERATURES. *J. K. Childs and M. M. Lemcoe, Southwest Research Institute. Aug '58. 275 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D.C. Price $4 (PB 151274)*

Aircraft and missile materials design criterin. Information on tension, compression and shear properties at temperatures from 75 to 1000 F. Tensile strength was severely reduced by increasing temperature.

Vinyl lacquer coating VINYL-LACQUER COATING FOR INTERIOR OF MILITARY STEEL PIPELINE TUBING. *S. J. Holzsweig, U. S. Army Engineer Research and Development Laboratories. May '57. 42 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1 (PB 151013)*

Tests show that vinyl lacquer coatings protect the interior of steel tubing against atmospheric corrosion during storage. The tests involved exposing coated tubing to gasoline, jet fuel and water.

Nickel-base alloys EXPLORATORY INVESTIGATION OF ADVANCED-TEMPERATURE NICKEL-BASE ALLOYS. *J. C. Freche and W. J. Waters, Lewis Research Center, May '59. 39 pp. Available from National Aeronautics and Space Administration, Washington, D. C. (No. 4-13-59E)*

Discusses a series of nickel-base alloys that generally provide good stress-rupture and impact properties for possible aircraft turbine blade or space vehicle applications. The strongest compositions displayed stress-rupture lives of 334 and 574 hr in the as-cast and homogenized conditions at 1800 F and 15,000 psi.

Spot test for epoxies A NEW SPOT TEST FOR EPOXY RESINS. *M. H. Swann, Aberdeen Proving Ground. June '58. 5 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 151032)*

Describes a new, rapid spot test for bisphenol-type epoxy resins. The test is said to be useful in routine identification of synthetic resins in coating materials.

Standard materials STANDARD MATERIALS. *National Bureau of Standards. Apr '59. 27 pp. Available from Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 35¢ (NBS No. 552)*

Lists standard materials issued by the Bureau and their prices.

Emissivity of oxidized metals MEASUREMENTS OF TOTAL HEMISPHERICAL EMISSIVITY OF SEVERAL STABLY OXIDIZED METALS AND SOME REFRACTORY OXIDE COATINGS. *W. R. Wade, Langley Research Center. Jan '59. 30 pp. Available from National Aeronautics and Space Administration, Washington, D. C. (No. 1-20-59F)*

Results of this investigation indicate oxidation of pure metals in air may be used to produce strongly adherent surface coatings with high emissivity. Values of total hemispherical emissivity were obtained for type 347 stainless steel and Haynes alloys C, X and 25.

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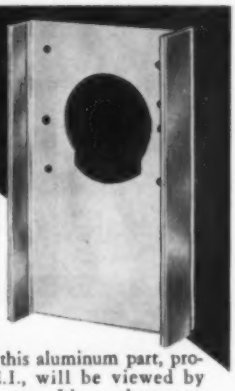

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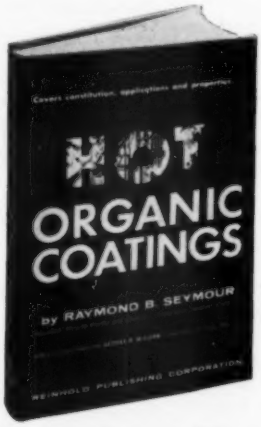
President, Alcylite Plastics and Chemical Corporation
with a special chapter by **GEORGE B. McCOMB**
Consultant to Leading Suppliers of Pipe Line Coatings

1959, 225 pages, $7.50

The constitution, applications and properties of hot organic protective coatings are concisely presented here. The book contains chapters on widely used hot organic materials such as asphalt, coal tar pitch, petroleum waxes and cellulose derivatives. Specific information on formulations of proprietary products is included. Additional chapters deal with hot melt applications without solvent such as peel coatings, protective linings, flame spraying and the fluidized bed process. One chapter on hot applied coal tar pitch base coatings is supplied by George B. McComb, consultant to the leading suppliers of pipe line coatings. Hot spray techniques and the many advantages of this application are also covered. This book will be helpful to everyone using these coatings in any form.

CONTENTS: Coating Fundamentals; General Discussion of Hot Coatings; Asphalt and Related Products; Coal Tar Pitch; Petroleum Waxes; Synthetic Hydrocarbons Resins; Cellulose Derivatives; Animal, Vegetable & Insect Waxes; Miscellaneous Products; Applications in the Absence of Solvent; Hot Applied Coal Tar Pitch Base Coatings; Hot Solution Applications; Tests; Trends and Potentials of Hot Coatings; Glossary—Trade Names; Index.



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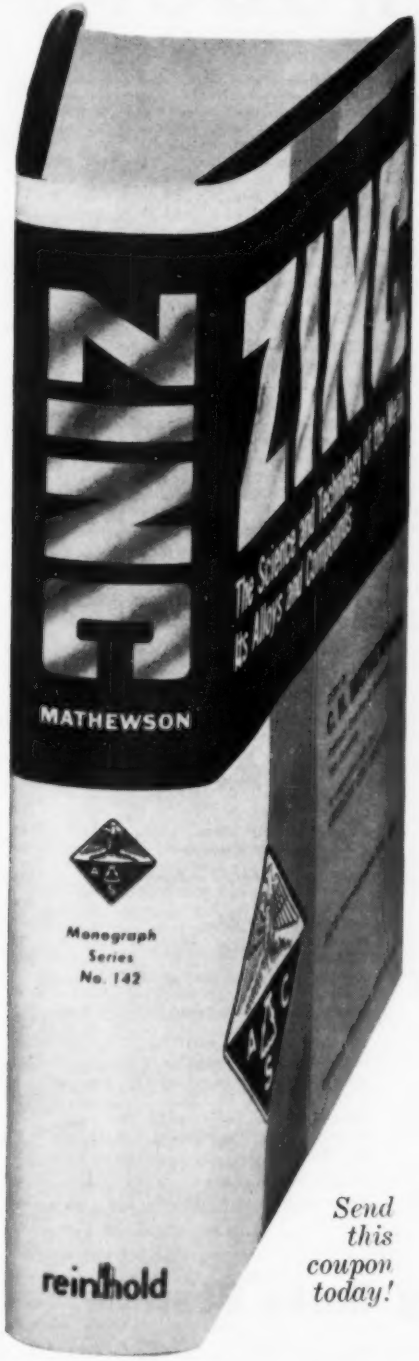

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Alleghony Ludlum Steel Corp. 29
Allied Chemical Corp., Plastics & Coal Chemicals Div. 74, 75
Allied Research Products, Inc. 180
Alloy Products Corp. 181
American Brass Co. ..... 2nd Cover
American Felt Co. 18
American Latex Products Corp. 204
American Metal Climax, Inc. 81
American Smelting & Refining Co., Federated Metals Div. 45, 46, 47, 48
American Steel & Wire Div., United States Steel Corp. 24, 25
Anaconda Aluminum Company 130
Armco Steel Corp. 49
Auburn Manufacturing Co. 201

Bost, Richard, Pencil Co. 159
Bethlehem Steel Co. 15, 149
Bunting Brass & Bronze Co. 138

Cameron Iron Works, Inc. 139
Cannon-Muskegon Corp. 165
Carborundum Co. 198
Carlson, G. O., Inc. 76
Celanese Corp. of America, Plastics Div. 163
Centralab Div., Globe-Union, Inc. 60
Cerro de Pasco Sales Corp. 211
Chace, W. M., Co. 196
Chromalloy Corp. 146
Clad-Rex, Div. of Simonix Co. 169
Colonial Plastics Manufacturing Co. 166
Columbus Coated Fabrics Corp. 172
Commercial Plastics & Supply Corp. 201
Conforming Matrix Corp. 159
Continental-Diamond Fibre Corp., Subsidiary of Budd Co. 171
Corning Glass Works 161

Dennis Chemical Co. 208
Dodge Steel Co. 167
Doltin Corp. 153
Dow Corning Corp. 127, 128
Driver, Wilbur B., Co. 148
du Pont de Nemours, E. I., & Co., Inc., Elastomer Chemicals Dept. 141
du Pont de Nemours, E. I., & Co., Inc., Film Dept. 199
Duraloy Co. 140
Durez Plastics Div., Hooker Chemical Corp. 73

Eastern Stainless Steel Corp. 137
Eastman Chemical Products, Inc., Chemicals Div. 136
Engelhard Industries, Inc. 70, 71
Enjay Co., Inc. 65

Fasson Products Div., Avery Adhesive Products, Inc. 153
Formica Corp., Subsidiary of American Cyanamid Co. 58
Frontier Bronze Corp. 207

General American Transportation Corp., Kanigen Div. 32
General American Transportation Corp., Plastics Div. 195
General Electric Co., Silicone Products Dept. 143
General Extrusions, Inc. 212
Goodrich, B. F., Chemical Co. 5
Goodrich, B. F. Co. 6
Goodrich-Gulf Chemicals, Inc. ..... 3rd Cover
Great Lakes Steel Corp., Div. of National Steel Corp. 62, 63
Gries Reproducer Corp. 208

H & H Tube and Manufacturing Co. 53
Hamilton Foundry Inc. 160
Handy & Harman 193
Harshaw Chemical Co. 66, 67
Hexcel Products, Inc. 56
Hydroforming Company of America 201

Indium Corporation of America 153
Industrial Metal Protectives, Inc. 144
International Nickel Co., Inc. 2, 58, 59

Jessop Steel Co. 61
Johnston & Funk Metallurgical Corp. 207
Jones & Laughlin Steel Corp., Stainless and Strip Div. 43

Kopp Glass, Inc. 156

Lancaster Glass Corp. 168
Latrobe Steel Co. 69
Lead Industries Association 209
Lepel High Frequency Laboratories, Inc. 203

MacLean-Fogg Lock Nut Co. 64
Malayan Tin Bureau 200
Mallory-Sharon Metals Corp. 34
Marbon Chemical Div., Borg-Warner Corp. 135
Metallizing Engineering Co., Inc. 177
Metals & Controls Div., Texas Instruments Inc. 78
Met-L-Wood Corp. 188
Milford Rivet & Machine Co. 202
Minnesota Mining & Manufacturing Co., Chemical Div. 190
Molded Fiber Glass Co. 210
Morganite, Inc. 150
Mycalex Corporation of America 17

National Carbon Co., Div. of Union Carbide Corp. 147
National-Standard Co. 50, 51
National Tube Div., United States Steel Corp. 173
Naugatuck Chemical Div., United States Rubber Co. 33
Neilson Chemical Co. 211
Northwest Chemical Co. 205
Norton Co., Refractories Div. 72

Ohio Rubber Co., Div. of Eagle-Picher Co. 175
Olin Mathieson Chemical Corp., Metals Div. 155
Olsen, Tinius, Testing Machine Co. 184

Page Steel & Wire Div., American Chain & Cable Co., Inc. 197
Parker Rust Proof Co. 82, 83
Phillips Chemical Co., Plastics Sales Div. 84, 85
Porter, H. K., Co., Inc., Riverside-Alloy Metal Div. 186
Precision Tube Co. 210
Production Die Casting Co. 194

Raybestos-Manhattan, Inc., Plastic Products Div. 152
Reeves Brothers, Inc., Vulcan Rubber Products Div. 14
Reichhold Chemicals, Inc. 13
Reinhold Publishing Corp. 142, 202, 212, 213, 215
Republic Steel Corp. 86, 87
Resistoflex Corp. 164
Reynolds Chemical Products Co., Div. Stubnitz-Greene Corp. 182
Richardson Co. 162
Rockwell-Standard Corp., Stamping Div. 206
Rogers, Dayton, Manufacturing Co. 211
Ryerson, Joseph T., & Son, Inc. 88

St. Clair Rubber Co. 212
St. Joseph Lead Co. 20, 21
Sandvik Steel, Inc. 158
Saunders, Alexander, & Co. 207
Sel-Rex Corp. 206
Set Screw & Manufacturing Co. 204
Sharon Steel Corp. 30, 31
Shell Chemical Corp. 8
Shenango Furnace Co., Centrifugally Cast Products Div. 178
Simmons Fastener Corp. 185
Spincraft, Inc. 159
Stackpole Carbon Co. 170
Swedlow, Inc. 28
Sylvania Electric Products Inc., Parts Div. 151
Synthane Corp. 44

Thompson, H. I., Fiber Glass Co. 79
Timken Roller Bearing Co., Steel & Tube Div. ..... Back Cover
Tinnerman Products, Inc. 80
Titanium Alloy Manufacturing Div., National Lead Co. 157
Torrington Co., Specialties Div. 174

Union Carbide Metals Co., Div. Union Carbide Corp. 145
Unitcast Corp. 154
United States Steel Corp. 26, 27, 54, 55
Universal-Cyclops Steel Corp. 22, 23

Vanadium Corporation of America 189

WalMet Alloys Co. 200
Washington Steel Corp. 176
Waukesha Foundry Co. 16
Weckesser Co. 203
Weirton Steel Co., Div. of National Steel Corp. 52
Westinghouse Electric Corp., Materials Manufacturing Dept. 179
Whistler, S. B., & Sons, Inc. 203
Williams-Bowman Rubber Co. 211
Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc. 192
Witco Chemical Co. 77
Wolverine Tube Div., Calumet & Hecla, Inc. 57
Wyman-Gordon Co. 187

Yardley Plastics Co. 9
Youngstown Sheet & Tube Co. 183

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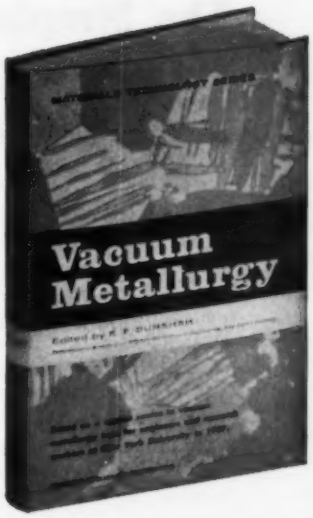

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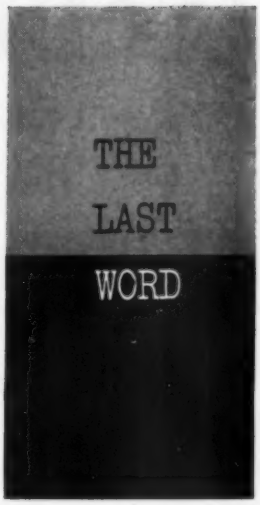

The Simpler Materials Specifications of Tomorrow

by H. R. Clauser
Editor

When, where and how new materials are used by industry largely depends upon the specification(s) developed for the materials. Therefore, specifications are an indispensable part of our materials technology. Because of the vital role they play in the acceptance and successful use of materials, it is important for specifications and standards to keep abreast of the rapid advances being made in the field of materials.

Traditionally, the development of specifications has been a long, slow process, often involving lengthy test programs and much debate and discussion. Despite shortcomings, however specifications usually have kept pace with new developments.

But now, new materials, complex combinations of materials, ultra-high-purity materials, and new ways of processing and treating materials are being developed at an unprecedented rate. To be responsive to the new and complex demands of our exploding technology, it is quite likely that we may need a new approach to standardization—an approach that will involve new kinds of specifications, produced in a much shorter time than is now required.

New specs will deal with atoms

What will this new kind of specification be like? C. A. Hochwalt, vice president for research, development, and engineering at Monsanto Chemical Co., predicts that it will be much simpler than those of today. He says the specification of tomorrow will "conceivably describe molecular type, size, and atomic geometry in terms of a very few numbers. It could originate with the scientist or engineer who, in defining the performance requirements for a material, would specify (its) fundamental atomic and molecular parameters." Thus, the standard would deal with fundamental rather than secondary properties, and the precise behavior of materials under a given set of conditions could be precisely predicted.

Perhaps it is only with this or a similar approach that our specifications can move ahead as rapidly as our expanding technology. But before such specifications can become practical realities, there is much work to be done. It will be necessary to gain a better understanding of atomic and sub-atomic structure and behavior. We will need to know more about how to manipulate molecules and atoms to give us precise, predetermined performance properties at the macroscopic level. And new advanced instrumentation and techniques will have to be developed.

ASTM faces the challenge

A large part of the job of developing the materials specifications of tomorrow must fall to the American Society for Testing Materials. This organization is well aware of the new problems and the need for new approaches to standardization, and it has begun to organize for the future. A few months ago ASTM established a new Division on Materials Sciences. Its objectives are to focus attention on, encourage, and coordinate work on the fundamentals of materials. Also, an Administrative Committee on Research has been active now for several years encouraging and assisting the technical committees of the Society in their research efforts.

Both of these new groups are still in the formative and planning stages. There are many problems of scope and organization to be solved. And much thought must be given to how best to implement the new objectives. This, then, is the "talking" stage. Although planning and discussion are quite necessary, the sooner we can proceed with the "doing," the sooner we will have the specifications of tomorrow.

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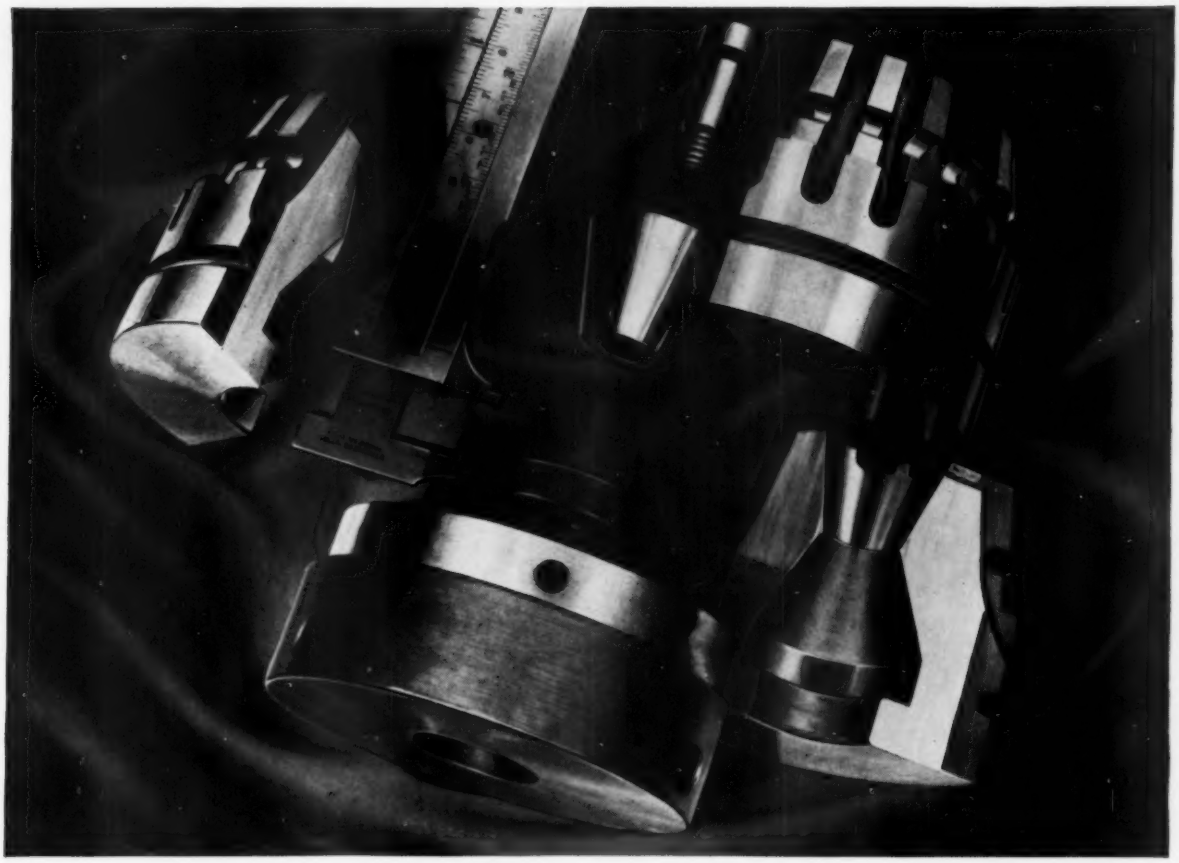

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